LECTURES

ON

GEOLOGY;

BEING OUTLINES OF THE SCIENCE

DELIVERED IN

THE NEW-YORK ATHENÆUM.

In the year 1825.

BY

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NEW-YORK:

PUBLISHED BY E. BLISS & E. WHITE, 128 BROADWAY.

H. SPEAR, PRINTER.

1825.

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When the Lectureship on Geology was instituted in the New York Athenæum, it was not supposed that the class of students would exceed 30 or 40 young persons, novices in the science. The brilliant success that has attended the establishment of the Institution was not then anticipated. It was with no small degree of reluctance and timidity therefore that the Lecturer addressed a large and enlightened audience. Nor was that timidity less than the satisfaction he afterwards experienced, on being advised by those who are admitted to be capable of judging, to submit the Lectures to the public.

The Lecturer has been the more willing to publish these outlines, since in this country, Geology is generally considered as embracing a knowledge of rocks merely, or positive geognosy; whereas, that study, though a very interesting and valuable one, is, in fact, but a part of the science. There is no work published, it is believed, that even hints at the many important points properly treated of under the head of geology; most authors on this

subject having confined themselves to Theories and Rocks. Nor is there any work that from its size and arrangement and authority is well calculated to be placed in the hands of the student. It is hoped that the present volume, while it offers in the plainest possible language, a more extending outline of the science, is sufficiently condensed for that purpose; and that it will fill, in some measure, the gap so universally acknowledged to exist, until a more general and more able production shall supercede it.

It is by no means intended to impress upon the reader a belief that these Lectures are the result of personal observation. On the contrary, much of what is found in the following pages is distributed through the writings of preceding enquiries. Numerous and extensive opportunities for the study of geological phenomena in Europe and America may have given the Lecturer some right to form his own opinions; yet as these have generally coincided with the ideas of others, liberal resort has been made to Humboldt, Macculloch, Conybeare, and Phillips, &c. &c. and it is believed ~~that a~~ comparison of the views and observations of such philosophers will vouch for every fact stated in this work. J. V. R.

Feb. 22d 1825

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LECTURE I.

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While we are prospering in Commerce and the Arts, it is gratifying to every liberal mind that Science is cherished in our country, and that the great cause of intellectual improvement has become one of the most popular.

When the Sun of Science, towards the close of the 15th century, dawned on Europe, from the dark cloud, which, for nearly 400 years, had en-

rapt intellectual progress, there were but four classics in the Royal Library of Paris: France and England were in barbarism; America undiscovered.

A taste for polite literature was first spread over the west of Europe by the fall of the Eastern Empire, and the consequent dispersion of the Greeks. It was enhanced by the noble discovery of the Art of Printing, which secured to itself the patronage afforded by the enlightened and liberal minds of a succession of Popes. They encouraged learning and the sciences, and in disseminating them, gave full assurance of the perpetuation of this valuable Art, and of the progressive improvement of human knowledge. But Philosophy was not courted with the zeal paid to Literature: Aristotelean maxims continued to be universally received until the 17th century, when Bacon, Lord Verulam, the profound philosopher, and most universal genius of any age, dissipated the mist of error, and threw a blaze of light on useful science, by which experiment and observation were discovered to be more convincing than system and hypothesis.

In slightly adverting, as I have done, to Peripatetic philosophy, it is unnecessary to recall your

attention to the school of Plato, the father of ancient philosophy; or to follow the division of his school by Zenocrates and Aristotle. However delightful the task, we shall refrain from entering and enjoying the Academy of the one, nor shall we walk in the delightful suburban grove of Athens, with the other. We need not trace that philosophy which was patronised by Julius Cæsar and Augustus; which was taught by Alexander of Anaphrœdeseus; introduced among the Jews by Aristobolus, and among the Arabians by Al Mamon. To this omission I am the more reconciled, since a learned exposition of that school has already been laid before you, in the eloquent discourses of my colleague, on the history of the philosophy of the mind. I must be allowed to say, however, that it was that philosophy, which in the earliest ages of Christianity rendered itself obnoxious to the church, by its doctrine of the eternity of the world. Still it forced its way within the Christian pale, and re-established its reputation: and from the 5th century the Aristotelian philosophy rose or fell with science in general, until its inconsistency with religion and true philosophy was exposed, at the period I have mentioned, by Bacon, the father of experimental philosophy.—Bacon!

unhappy name in the annals of science! "the wisest, brightest, meanest of mankind,"—a blazing beacon, to show us the fallacy of man in founding his reputation on literary or scientific attainments, not supported by moral principle—to show us that genius and talents, when not connected with virtue, "but lead to bewilder and dazzle the blind."

By the happy constitution of society in this country, few are enabled to devote themselves exclusively to the study of nature. As in politics and in morals, so in literature and in science, we form individually but separate links, which, when united, become one strong chain. Like the federal government, which is composed of, and upheld by, our different states, so the republic of literature must depend on the combined exertions of many.

Our local position, our government, our freedom of religion, are all peculiar to us; but not so our literature; that we possess in common with Europe, nay, with Britain only. With different laws, opposite governments, and in different hemispheres, America and Britain enjoy, in the same language, a common fund of literature, to which they both add according to ability, and whence they both draw according to inclination. Accord-

ingly, the Naturalists of Europe send us frequent and important acquisitions in the sciences, and we endeavour to repay the obligation by our researches on this side of the Atlantic.

It is within the recollection of many of those, whom, by the partiality of my Associates, I have now the honor of addressing, when the *terms* of Science were scarcely understood among us. Knowledge is not stationary: its progress is rapid, or it retrogrades. It may here be emphatically said, that "he who is not with us, is against us." Mental exertion and mental improvement have kept pace with each other, until the present state of Science and Literature was perfected.

The interior of our planet is occupied by shapeless and numerous masses, lying on each other in a certain order. To discover their nature, arrangement, and relations, is the part of Geology.

The various substances scattered through these beds, having in common with their matrices, certain laws of their own, peculiar to each species, it is the business of Mineralogy to collect and describe. They are bodies without motion, power or life.

The vegitable carpet of nature, which covers our planet, "the grass, and herb yielding seed after his kind, and the tree yielding fruit, whose seed was in itself, after his kind"—organised bodies, with life, but no sensation, belong to the department of BOTANY.

These three departments, it will be seen, derive much assistance from CHEMISTRY, which treats of those events or changes in natural bodies, which are not accompanied by sensible motions.

Man, made in the image of his Creator, and to whom "He gave dominion over the fish of the sea, the fowl of the air, and over the cattle, over every living thing that moveth upon earth, over every herb, and every tree—man, with all the subordinate and less perfect animals, is made the province of ZOOLOGY.

It is my lot to treat of GEOLOGY—and I propose at the present time to give a rapid sketch of the rise and progress of this Science, and the various Theories that have been published in illustration of it. This I am the more emboldened to do, because, as Stewart says, it is not from his own erro-

neous hypothesis alone that the philosopher is assisted in the investigation of truth. Similar lights are often to be collected from the errors of his predecessors: and hence it is, that accurate histories of the different Sciences may be justly ranked among the most efficient means of accellerating their future advacement.

It was from a view of the endless and hopeless wanderings of preceding enquirers, that Bacon inferred the necessity of avoiding every beaten track: and it was this which encouraged him—with a confidence in his own powers amply justified by the event—to explore, and to open a new path to the mysteries of nature.

Inveniam viam, aut faciam.

There is no subject, says Fontenelle, on which men ever come to a reasonable opinion, till they have once exhausted all the absurd views it is possible to take of it. What follies, he adds, should we not be repeating at this day, if we had not been anticipated in so many of them by the ancient philosophers.

Those systems, therefore, which are false, are by no means to be regarded as totally useless. That of Ptolemy, as Bailly observes, is founded on a prejudice so natural and so unavoidable, that it

may be considered as a necessary step in the progress of astronomical Science: and if it had not been proposed in ancient times, it would infallibly have preceded among the moderns, the system of Copernicus, and retarded the period of its discovery.

Should any one say that after all, our theories are but hypothesis, I would beg you to call to mind, that it was by the happy hypothesis of a ring encircling the body of Saturn, that Huyghens accounted in a simple and satisfactory manner for all those appearances, which for years had puzzled all the astronomers of the world. Of the accuracy of this hypothesis no reasonable doubt can be entertained, when it not only explains all known phenomena, but enables the astronomer to predict with accuracy those which are afterwards to be observed.

The earliest published theory of the earth with which we are acquainted is that of Burnett.*

He supposed that the primeval earth was a fluid mass, composed of heterogeneous materials, the heaviest of which descended to the centre, and there formed a hard and solid body. Around this

* "Telluris Theoria Sacra." London 1680.

body was collected the water: and all the lighter fluids, the air particularly, ascended above the water, and encompassed the whole. Between these orbs of water and air was an oily matter, upon which the impure earthy particles, blended with the air, descended, and uniting with it, formed the crust of the earth, which became habitable and was the abode of men and annimals. In this state, as its equator coincided with the plane of the ecliptic, there was no variation of season—"and one unbounded spring encircled all."

The surface he supposed to be smooth and uniform, without mountains, seas, or inequalities—nor did it vary at all for 16 centuries, when the heat of the sun dried the crust, and caused it to crack into fissures or crevices, which eventually deepened and penetrated through it. These fissures enlarged and the enclosed waters gushed out with much violence, and in such quantities, as to cover the dry land, and occasion the general deluge. The water at length retired into cavities, and as these became filled, the earth appeared in its most elevated parts, and formed mountains, while the lower parts remained covered by water, and formed vallies, oceans, &c.

The beauty of language in which Burnett clothed his theory enabled him to throw a kind of splendour over his erroneous ideas, which forced them for a time into general acceptance. It has been asserted, I know not upon what authority, that this theory had been previously published by Francisco Patrizio, a professor at Rome, in a dialogue called "Il Lamberto." It is generally viewed as an elegant Romance; the product of mere imagination, unsupported by any observed phenomena.

About the same period the celebrated Leibnitz published his "Protogœa," in which he holds that the earth and all planets were originally fixed and luminous stars, which for ages had blazed in the firmament, until the combustible matter was exhausted, when they lost their brilliancy, and became opaque bodies. The fire, by fusing the earthy matter, vitrified it, so that the base of all things belonging to the earth is glass, of which sand and gravel are fragments. The other earths are a combination of sand with water and salts. When this crust cooled, the aqueous particles, which had arisen as vapour, were condensed and precipitated, forming the ocean. These at first covered all the earth, and the shells and other marine products are proofs of the fact.

Woodward next appears on the list of theorists.* He observed several phenomena with attention, but was only partial in his observations. He noticed marine exuviæ, and supposed them left on land by the subsidence of the ocean. That while the waters of the deluge covered the earth, all solid substances were held by them in a state of solution. That eventually a precipitation of all matters occurred in the order of their specific gravity—the heaviest first, and the rest in order. That consequently these strata were all parallel and spherical, and encompassed entirely by the great ocean. That in the course of time some powerful internal agent broke these strata universally, and changed their relative positions, elevating some and depressing others—thus producing mountains and valleys:—in fine forming the earth as it now exists.

It is not necessary, in the present state of this science, to urge arguments against this or the preceding theory. Suffice it to say, that the mere existence of beds of light substances placed beneath many of greater specific gravity is at once an objection that cannot be removed.

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* Essay towards the Natural History of the Earth and terrestial bodies by John Woodward M. D. London 1702.

The internal agent alluded to by Woodward was probably the same mentioned by Dr. Hook, who in his "Discourse on Earthquakes," published in 1688, assumes that the bottom of the sea had been elevated by these tremendous convulsions of nature, caused by subterranean fires; and he thus accounts for the existence of shells on the summits of mountains.

Dr. Halley* ascribes the deluge to the shock of a comet, or some transient body, by which the polar and diurnal rotation was immediately changed, causing thereby a great agitation in the sea. Thus he accounts for all the strange varieties of position we see on the surface of the earth; as high mountains standing on beds of shells that were once the bottom of the ocean, &c. &c. It may be observed that so violent a shock would cause all fluids to run instantly to the part where such a blow was given, and with such a power as to carry along with it the bottom of the ocean.— But then the deluge must have been produced very rapidly, and by no means in the gradual way in which we are taught to believe that it happen-

* Phil. Trans. No. 383.

ed, both by scripture. and the observance of phe-
nomena.

Catching the idea of Halley, and blending with it the views of his predecessors, of Woodward more particularly, Whiston erected his theory* on mathematical calculation, founded on his assumed data. He endeavours to show, that on the first day of the deluge, a comet, descending in the plane of the ecliptic, towards its perihelion, passed just before the earth, and, coming below the moon, caused, by its power on the tides, the elliptic figure of the earth; which broke, and the waters, issuing through the crevices or fissures, produced the deluge, in conjunction with the rain that descended from the comet on its return.

At first, the author advanced all this by way of hypothesis only, but afterwards became persuaded of the truth of a conjecture, for which there is not the least semblance of foundation.

In 1740, Lazoro Moro, an Italian, is said to have brought forward the idea, that not only mountains, but the whole earth was raised from the bottom

* "New Theory of the Earth." London 1708.

of the ocean by the power of combustion, that commenced soon after the creation. That the portions of earth which now exhibit no marine shells, were elevated before the fish had stocked the ocean; but that afterwards shells and fish were thrown up, and deposited in strata along with the soil. This theory has been adopted at a later period.

De la Bryme* supposes that the Antideluvian world had, besides mountains, rivers, &c. an external sea, and that the falling in of immense internal caverns, accompanied by earthquakes. swallowed up most or all of it, leaving the seas only visible. From the bottom of this sea arose our present earth, in the same way that some islands have been swallowed down, and others thrust up in their stead, even in the present day.

There are many valuable and interesting facts in accordance with this theory, which has been partially upheld by Mr. King, at a much later period.† He accounts for the deluge wholly by subterranean fires, which burst with great vio-

* Phil. Trans. No. 266.

† Phil. Trans. vol. 77

lence beneath the sea, and raised its bottom, so as to throw its waters over the land, where they have since remained; so that the dry land and ocean changed places, what was covered by the ocean becoming dry, and the waters resting on the land.

We can scarcely believe, however, that the former world was completely destroyed, as is supposed by M. Deluc, who enlarged on this hypothesis, since we are told that Moses took the appearance of an olive branch to be a sign of the diminution of the flood. This could not have been supposed to be a submarine production; nor are we at liberty to suppose it the produce of an island that had escaped the general inundation.

In 1746 Guettard first complied with the wishes of Lister, who, in 1684, recommended the adoption of geological maps. He was one of the first writers who seems to have forsaken cosmogony, and applied himself to geological enquiries. He possessed, for that period, much important information, which led him to pretty correct conclusions: for instance, he formed 3 divisions of the earth's surface. The first he called *Schistose*, which embraced the primary rocks:---secondly

the *Marls*, which included the secondary, pretty generally; and thirdly, *Sand*, coinciding with what is now termed tertiary. His views were too extensive for the state of the science at the time in which he lived.

Lehman, who directed his mind to this subject, soon discovered and demonstrated the distinction between primary and secondary rocks, illustrating his ideas by the geology of the Hartz. Like the peasant of Virgil, who imagined his native hamlet the miniature of imperial Rome, Lehman imagined the Hartz and the Erzeberge a miniature of the world. It is needless to say that they were about equally correct.

Mr. Whitehurst studied diligently some parts of England, for many years, and being a close observer, he collected very many facts, whence he proceeded to erect a theory,* in which the two great agents are expansion and gravity: the former derived from internal fire, and the latter from an accumulation of earthy particles. The expansive force at last gaining the ascendency,

*"Inquiry into the original state and formation of the earth." 1786

broke through the superincumbent mass, and forced up the strata in all directions. The globe was afterwards broken into comparative fragments by the explosion of steam, and the primitive state of the earth completely changed: and even the Alps, Pyrenneess and Andes thus brought from the abyss. For the truth of his opinions the author refers to fossils. There is some romance, and much valuable information in his book.

Kirwan, an Irish philosopher of strong mind and extensive erudition, not believing in the theories of his predecessors, turns at once to the account of Moses, as the only one consistent with actual phenomena; and ascribes the Deluge to a supernatural cause—the express intention of God to punish the crimes of mankind. He says the deluge was a miraculous effusion of water from the clouds and from the great abyss, and which was sufficient to cover the whole earth. This he establishes by a reference to the laws of the Newtonian theory. Having proved this fact, he proceeds to state that the deluge commenced in the great southern ocean, below the equator, and rushed thence to the northern hemisphere.* He

* Vide Trans. of Roy. Ir. Acad. vol. 6.

brings the following arguments in support of his views, viz.—

1. That the southern ocean is the largest collection of water on the globe.

2. In northern latitudes we observe the remains of Animals from the southern continents and ocean, but in southern climates no remains of northern animals of land or water.

3. The traces of a violent shock from the south are still visible in many countries.

4. The shape of continents, all sharpened to the south, where they are washed by the southern ocean, indicate the force of the shock, which mountains only could withstand; such as the cape of Good Hope—cape Comorin—the south point of New Holland and Patagonia.

It will be observed that Kirwan endeavoured to go by the Mosaic account; which, although not intended, as some writer remarks, as a geological record, is still upheld by the geology of the present day.

We do not believe, with some authors, that it indicates presumption, to scan the works of the Almighty,—to attempt explanations of the deluge, or any physical cause,—nor to offer conjectures as to the results. His power was wonderfully and

miraculously displayed in that awful catastrophe, for the completion of which the operation of physical causes seems to have been direeted, and the laws of nature to have been suspended. In studying the manner in which these changes were wrought, or their ultimate effects, we see no presumption, no doubt of the omnipotence of the Ruler, no disbelief in the wisdom of the Allwise Sovereign.

As no theory that had been issued came clothed in the beauties of language or boldness of conception comparable to that of M. Buffon, so none has ever been so popular, for the fund of information it contains. The prominent points only can be hinted at.

He supposes that the Earth and other planets formed, originally, parts of that glorious orb, whence we, at least, derive our light and heat: and to have been detached by an oblique stroke of a comet. These portions of igneous matter, forced thus from the Sun, assumed a globular shape by the attraction of cohesion, and receded to such a distance as to allow them to gain an eliptical motion round the parent Sun, where they are now retained by the conjoined effect of cen-

tripetal and centrifugal forces. By the rotary motion, and the fluidity of matter, the earth gradually became an oblate spheriod. It eventually cooled, and the aqueous atmosphere condensing by degrees, descended upon the surface in form of water. This water deposited sulpherous, saline, and other matters, which entering into fissures, &c., formed metallic veins and minerals: and part resting on the surface, produced mould. The internal part, he says, were, and still are vitrified: the upper surface, being pumice and scoriæ, were acted on by the water and other agents, and produced clays and soil. In this state the tides and the winds and the heat of the sun began to produce strong effects. *The diurnal* motion of the earth, and the power of the tides, elevated the waters around the Equator, and carried there, from higher latitudes, great quantities of slime, sand, clay, &c., thus elevating the equatorial, and depressing the polar regions. Thus. he says, we observe the highest mountains within the tropics, and there the irregularities of surface generally are greater than at the poles. The action of water in the scoriæ, produced excavations in some places, and elevations in others, which in course of time formed islands and continents.

The destruction of mountains, and the formation of new islands, with all the various positions of strata, so unaccountable by all other theories, he endeavours to reconcile by the chaotic confusion thus produced.

The bottom of the sea, he says, resembles, in its regularity, all the varieties of inequality, of hill and dale, earth and rock, that we observe on dry land. Its plants and shrubs have a similar regular distribution. As we find under the equator the highest mountains, so there do we find the deepest seas. Incontrovertible facts, he thinks, prove, that as the dry and habitable portion of the earth has been once for a long period under water, so similar changes are now going on at the bottom of the ocean, which will eventually become dry land: but not in an immense period, since the operation of like causes do not produce like effects in the same time now as formerly.

All continents and islands have their mountains in the centre, dividing them longitudinally. From these the rivers run perpendicularly to the ocean, in which they empty, wearing away mountains, producing vallies, and making deposits at their mouths, which are carried into the ocean, to form new beds, new islands, and new continents: and

eventually to restore to the dominion of ocean the realms which are now beyond its waters—and whose rocky barriers and broken coasts seem to hold the language of the flatterers of Canute—"thus far shalt thou come, and no farther."

In noticing this theory, I must be allowed to say, that it was only about the time of its publication, that Geology first claimed the rank of a science. Before this period, scarcely an accurate idea had been formed on the subject. The few rays of light were scattered, until an unexpected nucleus attracted the wandering atoms, and drew them together. The brilliant genius of Buffon diffused a radiance on philosophical enquiries. It wasted itself in unprofitable theories, but threw a distant light upon the practical enquirer. This is the only subject on which the splendid genius of the naturalist shed no immediate light: smaller stars, however, were rendered perceptible by his reflected rays.

All these theories are vague, and insufficient to account for existing facts; besides that they partake too much of the ancient cosmogony for the present day.

There are but two other theories of consequence; and these we shall but slightly touch upon, intending in the course of our duties to refer to them sepa-

rately, and view their opposing principles. I shall have been anticipated by many of you when I mention that these are the celebrated theories of Dr. Hutton of Edinburgh, and of Prof. Werner of Freyburg.

Dr. Hutton published his theory in 1788.

He considers the Earth as a mere machine—describes its mechanism—and enumerates the powers by which motion is produced, and activity communicated to it. These are the projectile power, gravitation, the influence of light, heat, cold, condensation, electricity, and magnetism.

Observing that a solid body of land could not answer the purposes of an inhabitable world without a soil suited for vegitation, he says that this soil is formed merely by the decomposition of the solid earth. The surface inhabited by man, and covered by plants and animals is made by Nature to decay—that the interior constantly furnihes soil which is as constantly washed away by the continual action of water running from the mountains to the ocean: that thus heights are levelled, fertile plains formed from the disintegration of mountains and rocks, and the materials carried on to the abyss of ocean. This soil is constantly formed and removed, and thus the land

tending constantly to destruction. To counteract this Dr. H. supposes the constitution of the globe to possess a reproductive operation, by which this ruined and decayed world becomes again repaired; and that the apparent destruction of the earth's surface is in fact the real cause of its renovation. While this change is going on, new strata become consolidated by internal heat: all solid land is formed at the bottom of the sea, and elevated by fire, inaccessible to be sure to human observation, but still existing and operating. Simple fusion, then, is considered as giving hardness and solidity to the different strata that have been condensed by means of it. According to this Theory the secondary and newer rocks were deposited at the bottom of the ocean, in consequence of operations similar to those now in action, and the primary were formed beneath, by internal fire. All marbles, limestones, &c, are composed of the calcareous matter of marine animals.

In this theory there is a happy union of the agency of both fire and water; the one collecting and depositing, the other consolidating and elevating.

This system is in unison with many facts as seen in Scotland where it originated. It has been ably

supported by the elegant illustrations of Professor Playfair. That classic scholar could see the ordinary operations of nature producing Geological phenomena, through an infinite succession of ages' without beginning and without end. The subject has been rendered interesting, independant of its author, by these illustrations, which are said to display advantageously its principles, argue forcibly in its favor, ingeniously combat the objections, and apparently establish its own conclusions.

This book continues to be the text book of the best English Geologists.

It will be remarked that this theory embraces many of the points held out by the philosophy of Aristotle, which, as formerly remarked, secured to itself, by its doctrine of the eternity of the world, the severest censures of the Fathers of the christian church.

It was about this time that Saussure visited and studied the Alps, whence he drew conclusions the most important to Geology. While he was thus engaged, Pallas was traversing the Russian empire, and, with the zeal of a master, accumulating facts for the establishment of the science.

Werner, a name almost revered in Germany, now appeared on the list of Geologists. As he published but little himself, his intrinsic merits can never be properly estimated. It is to be regretted that his apathy prevented him from publishing. His antipathy to the mechanical part of writing was so excessive as to be amusing. Nothing could finally induce to write a line; and to avoid reproaching himself with want of politeness, he at last would not open the letters addressed to him.

A certain author who wished to consult many philosophers respecting a voluminous work, circulated his manuscript and it was lost; after a thousand researches, it was disinterred at last, from among an hundred others, in possession of Werner. When the French Academy placed him among its eight foreign associates, an honor coveted by the most illustrious philosophers of Europe, he never opened his letters, and became acquainted with his honors through an Almanack. And to crown all, an express which his sister had sent to him from Dresden, waited two months, at an inn, at his expense, waiting his simple signature to some very pressing family concerns. He had sent his "System" to the press, but could never endure the fatigue of

correcting the first proof sheet. We know it, therefore, only as promulgated by his pupils; who looked upon him as the genius of his age, and blindly worshipped at his feet. They supposed that his ideas formed at once a mature system, elegant and perfect, they termed it geognosie, and inscribed on it the name of Werner. To this merit he was not entitled. He had a strong mind, which was divided, and gave its whole strength to minerals and systems. Method was his hobby. He was fond of dividing and classifying, and latterly bought books, not to study, but to arrange them in a certain order in his Library. He is said to have debated alike on the order of his dinner table and the arrangement of his cabinet, and even traced the military art by the laws of geology. "A man," said he, "who wishes to become a great General should begin his education by studying Oryctognosy and Geognosy, at Freyburg." It was his love of system and division that induced him to add to the primary and secondary, the intermediate transition, which has been likened to the increasing of primary colors by the addition of mixed tints. He multiplied divisions, but he did not strengthen them. His great error was in supposing that Saxony and Bohemia were the world in

miniature. Like Lehman, he supposed that what he had seen was all the world afforded: and that he had sufficient data in his own country whence to draw conclusions as to the universal structure of the world. None but his most attached pupils now uphold his theories, which he carried beyond the bounds of philosophy. His ardent zeal, however, diffused itself among his adherents, and he may justly be said to have done more than any other man for the advancement of Geology.

We have been detained, however, too long by the man, from his works. He threw aside hypothesis, and drew his arguments from facts.

His first proposition was that the Earth, to some depth, was originally fluid—not from fusion by heat, but from aqueous solution. These outlines are these:

1. The surface of the globe was originally soft or fluid, as inferred from its present shape, and geological phenomena.

2. That for centuries after its creation the earth contained in its inner parts immense empty caverns, but sufficiently solid to bear the superincumbent mass.

3. The materials composing the earth were at one period dissolved, and held in solution by wa-

ter) whence they have been consolidated and precipitated, partly by crystalization and partly by mechanical deposition; granite first, and the other primary rocks in order, principally by chemical precipitation.

4. From this date the waters rapidly subsided, retiring into the cavities of the earth. During this period other strata, the oldest secondary, (or transition) were deposited.

5. The further subsidence of the waters occasioned, by mechanical action, a partial disintegration, which furnished materials to unite with those still held in solution, which were then precipitated and formed the secondary horrizontal beds, abundant in organic remains.

6. During the gradual diminution of the waters, and the consequent hardening of the strata, rents and crevices were formed, into which the waters entered, still holding in solution metals, &c. &c. whence arise metallic veins and beds of metals.

7. That volcanoes and depositions from water are still producing changes on the earth's surface.

From the time of Pallas, Saussure, Hutton and Werner, the new science, which had lately arisen under the proud tittle of the theory of the earth, attracted the notice it merited. Celebrated men

became its pupils, and we find Humboldt, Cuvier, Daubuisson, Brongniart, Van Buch, Brochant, Brocchi and Maclure, with many others, giving their time to perfecting it: each adding his observations to the scale of one of the great masters, whence have been derived the absurd titles of Wernerian and Huttonian, or Neptunian and Plutonic Theories. The one attributing most geological phenomena to ingenious, the other to aqueous origin. Both are imperfect. Future observations will add valuable facts, and perhaps accumulated evidence will weigh in favour of the aqueous origin of most rocks.

Whatever may appear from a transcient glance, a complete examination of the opposing theories cannot leave the mind biassed much in favour of either. To the Huttonian theory, says Dr. Murray, its most violent opponent, belongs the praise of novelty, boldness of conception, and extent of views. Its author has aspired not merely to account for the present appearances of the earth, but to trace a system, in which the formation of successive worlds is developed: he has sought to extend that order and arrangement, that principle of balance and restoration, observed in all the de-

partments of nature, to the constitution of the globe itself, and he has succeeded in drawing an outline which gratifies the imagination with the semblance of grandeur and design.

An enumeration of the arguments in favour of this theory cannot be necessary to you. Suffice it to acknowledge that the relative position of mineral masses, their constituent parts, and the peculiarity of fossils render inadmissable the idea of a central fire, existing without an assignable cause, from eternity, and producing effects by no means commensurate with its power. We are not however to underate the agency of subterranean combustion: The known existence of nearly two hundred volcanic openings is sufficient proof of the extent of internal fires: and the vast distance at which the shocks they occasion have been sensibly felt, give some idea of the extent of their force, which even an intervening ocean cannot restrain.

The opposing theory, to which the name of Werner has been improperly attached, forms a simple contrast to improbable hypothesis. That the surface of the earth has been arranged by water, is proved by a knowledge of geological facts. In appealing to proofs from induction, we find actual phenomena in accordance with principles.

Perfection is not attainable in all things: while any science therefore remains in a state of imperfection, deficiencies must be discovered in the application of principles established by induction only. Such is the case with this theory, yet it offers no inconsistencies, contradicts no facts. It is a series of inductions, more or less perfect, referred to a common principle, and occasionally connected by a moderate and rational hypothesis.

It will have been noticed by all of you that no attempt has been made to explain the present appearances of the earth's surface without allusion to a period when it was inundated. No theorist has advanced an opinion in which such an event does not form one of the most prominent features. It becomes necessary, therefore, for one moment, to turn our attention to that epoch, one of the most remarkable in chronology.

Previous to the general deluge, we find by sacred and profane history, that there were several great floods: of which that happening in Greece, during the reign of Deucalion, is one of the most conspicuous. It is said to have occurred 1529 years B. C.—being the third year before the Israelites left Egypt—(or 1503 according to Blairs chronology.) This flood inundated all Thessally.

296 years before this flood, viz. 1020 years before the 1st Olympiad, and 1796 years B. C.—occurred the deluge of Ogyges, which ravaged Attica.

These floods have occasionally been confounded with that of Noah.

There are other floods on record, which may be barely named—The deluge in Syria which in 1095 A. D. drowned vast numbers of people—that which in 1164 deluged Friesland—and that which 1218 deluged the same country and destroyed 100.000 men.

The Netherlands and Brabant have been several times inundated and their whole surface materially changed.

The deluge, however, to which geologists allude, is distinguished as the universal or Noah's flood—and is recorded in scripture (Gen. 6 and 7th ch.) as sent by way of punishment for the vices and corruption of that age.

The period of its occurrence is stated by the best chronologers, to have been 1656 years after the creation, or 2348 years B. C.—and 4173 from the present year. On the 10th day of the second month, which answers to Sunday, Nov. 30th, Noah and his family entered the Ark. On Sunday Dec.

7th, the rain commenced, and continued for forty days. On Wednesday May 6th (2348 B. C.) the ark rested on mount Arravat. The tops of the mountains became visible on Sunday, July 19th, and on Friday, Dec. 18th, Noah and family left the ark, and built an altar to God.

One hundred and fifty days therefore is the period it lasted—and during this time many of those changes took place which it is in some measure our object to account for.

It is a remarkable fact that this event is preserved in the memory of all nations. In our country, as well as in Africa, Asia, and Europe.

We are indeed told that the Gentoo traditions, neither written nor oral, make any mention of it, and that the Bramins assert it never took place in Hindoostan. Were this true, it would necessarily excite astonishment, since traditions of it have been traced in every quarter; not only among the Romans, Greeks, Egyptians, Babylonians, Persians and Scythians, but among our own Iroquois, among the Mexicans, Brazilians and Persians.

But Sir Wm. Jones asserts that traditions concerning a deluge do exist from Hisdoostan, and that their oldest mythological works preserved an account very similar to that of Moses.

It is asserted that some traveller, interrogating the inhabitants of Otaheite as to their origin, received for answer, that a long time ago, the supreme God, being angry, dragged the earth through the sea, and their island being broken off, was alone preserved.

I am not here however, to defend or uphold the accounts related in the Bible. It is a history however, which does derive support from Geology.

Although no geological theory has been broached on this side of the Atlantic, it is with much pleasure that I am enabled to turn our thoughts homeward, from the splendid constellation of European science, and survey the rapid strides of this branch in our own country. Twenty years ago Geology was known here by name only. It was about that period that the late Dr. Bruce returned from Europe with a splendid collection of minerals. His zeal and attainments, with the conjoined efforts of Col. Gibbs, gave an eclat tothe study of mineralogy, appropriately termed the alphabet of Geology, which has produced the most beneficial effects. It is needless to enumerate the long list of those who have since successfully promoted the interests and diffused the knowledge of mineralogy, serving as the foundation of geology.

It is not more than fifteen years since we had the first intimation through the press, that any of our citizens had observed the geological phéno- mena of our country. Dr. Mitchill and Dr. Arkerly, were among the foremost to enlighten us on the subject, in the first purely scientific journal established in our country.* Since then, we have been annually enriched by the exertions of our friends. No great standard work has yet been given on the geology of America; but the partial labours of individuals will soon afford ample materials for filling up the outlines now so well known, and which are more distinctly marked than in any other country.

The observations attached to the American edition of Cuvier's theory of the earth, and the numerous notices of the learned annotator in various periodicals have thrown abroad much information on the formation of North America.

The Essays of the indefatigable President of the Academy of Natural Sciences, at Philadelphia, have done much to advance this Science, and many of the members of that highly respectable society are zealously engaged in the same cause.

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* American Mineralogical Journal.

Mr. Hayden has published a vast accumulation of facts to prove that the whole region skirting the the Atlantic ocean is the result of the operation of Currents. He attaches much importance to this region, and has partially marked out the most interesting formation that we possess: I mean the Tertiary. The author has evinced a knowledge of his subject which it would be well for those to possess who oppose his views.

Dr. Akerly's Geology of the Hudson has been long before the public.

Mr. Pierce has described part of New Jersey and the Catskill mountains.

To Mr. Hitchcock we owe a minute and interesting sketch of the Geology and Mineralogy of the Connecticut river.

The Exploring Expedition sent by Government, under command of Major Long, to the Rocky Mountains, has greatly added to our knowledge of the secondary region to the west and north.

The gentlemen engaged in establishing the boundary line under the 6th and 7th articles of the Treaty of Ghent have afforded new information

concerning the country about the great Lakes and to the north west. Major Delafield, agent of the U. States, under those articles, and Dr. Bigsby of the British Medical Staff, attached to the commission, have laid us under many obligations by their very valuable contributions to our knowledge of that interesting region.

Mr. Schoolcraft is now engaged in the publication of a work from which we may expect to derive much valuable information relative to the geological structure of our western country.

To the Hon. Maj. Gen. Van Rensselaer, whose enlighted mind, and liberal views interest him in all branches of knowledge, we owe Geological and Agricultural Surveys of the district adjoining the Erie Canal and of the counties of Albany and Rensselaer.

Individual observations on particular regions are thus connecting links for the formation of one grand chain, which will eventually embrace all the strata, beds, veins, and minerals of our continent.

The bold outline of our primary range of country first attracted the notice of our geologists. The secondary has been explored in the grand with tolerable accuracy.

The alluvial has received a portion of attention; indeed under this term has been included until of late, the vast tertiary formation situate between the alleganies and the atlantic.

The vast number of beautiful fossils that we are constantly receiving from our secondary and tertiary formations go far towards proving that many of our rocks are precisely of similiar formation with many of those of Europe, and afford new proofs of the value of these remains as geological characters.

Allow me, for one moment, in concluding this sketch of Theories, to draw your attention to the striking similarity of the Records of Sacred History, and the phenomena of Geology. Upon a comparison, I think you will coincide with me in the assertion, that the Mosaic account of the structure of our globe is fully corroborated by the evidence afforded by the Science with which we are now engaged.

The account in Genesis may be summed up in three articles.

1st. That God was the original creator of all things.

2d. That at the foundation of the globe we inhabit, the whole of its materials were in a state of chaos and confusion.

3. That at a period not exceeding 5000 years, (according to both Septuagint and Hebrew Chronicle) the whole earth underwent a mighty catastrophe, in which it was completely inundated by the immediate agency of the Deity, and all its inhabitants destroyed, except the remnant miraculously preserved to continue the species. If to these great outlines of the sacred historian, we add that the materials of the globe were in a fluid state previous to its organization and that its organization was gradual, we embrace all the important points comprised in the Records—and all that the most zealous believer in inspiration is bound to maintain.

Let us now look to the phenomena of Geology, and see the conclusions drawn from their study and examination. These conclusions, condensed from the observations of Cuvier, the most acurate naturalist of the present day, may also be comprised under three heads.

1st. That the sea has at one period or other not only covered all our plains, but remained there for a long time and in a state of tranquility.

2d. That there has been at least one change in the basin of the sea which preceded ours: it has experienced at least one revolution.

3d. That the particular portions of the earth, which the sea has abandoned by its last retreat, had been laid dry once before, and had at that time produced quadrupeds, birds, plants, and all kinds of terrestial productions: it had been inundated by the sea, which has since retired from it, and left it to the possession of its own proper inhabitants.

Thus we see that the accounts of Moses, and the results attained by Geology, or the study of the structure of the world, coincide, and derive light and support from each other.

1. The prevalence of the waters at the period of the Creation described by Moses:

2. The separation of the land from the water, producing a revolution in the basin of the sea:

3. The irruption of the sea over the continent, are satisfactory coincidences between the Sacred Historian and the Geologist.

LECTURE II.

Objects of Geology—its utility to the Farmer, Miner, and Architect. Position of Rocks—division of them into classes. Observations on the Primary Rocks—on the Transition—Secondary--Tertiary—and Alluvial. Organic Remains. Divisions of the Earth's Surface—Bottom of the Sea—Dry Land—Low Land—Alpine Land. Mountain Groups and Chains. Observations on the Position and Declivities of Mountains. Vallies.

From the view of Theories which I have offered to you in the last lecture, it will be seen that Geology is the science purporting to illustrate the structure, relative position, and mode of formation of the different substances composing the crust of the Earth. It aspires to record events of that period of time, when not only the Earth, but the whole planetary system was uncreated. It is by induction only, however, that we explain phenomena, and assign causes to effects that have operated in former times, and thence down to the present day, through a succession of ages.

By induction is to be understood that process, by which, upon comparing a number of cases, agreeing in some circumstances, but differing in others, and all attended with the same result, a Philosopher connects, as a general law of Nature, the *event* with its *physical* cause.— According to Bacon "Inductio, quæ ad inventionem et demonstrationem scientiarum et artium erit utilis, naturam separare debet, per rejectiones et exclusiones debitas," &c. &c.—Nov. Org. Lib. 1, Aph. 10[illegible].

To the admirers of Nature's works, Geology offers new treasures of enjoyment, and viewing the sublime or beautiful scenery which surrounds him, he has greater cause than ever for admiration, in its powers of adaptation to the purposes of life; and exclaims with the melancholy, but pious Young—

> An humble, pure, and heavenly minded heart
> ——Is here inspired.

In referring to the phenomena of Geology, a pure and classic writer has observed, that, few questions are more calculated to excite the speculative enquirer, or more fascinating from the grandeur and novelty of the objects it brings before the mind. Nor can it be said to satisfy nothing but a vain curiosity. The maxim is too well established by the history of science to require

proof or illustration, that the consequences which may result from any physical discovery can never be foreseen, and that no investigation can be deemed unprofitable which may add to our knowledge of nature. A perfect Theory of the Earth, were it established, would undoubtedly admit of the most important applications, and a succession of Theoretical discussions may not less contribute to its attainment, than the accumulation of facts. With these last it is more particularly our business to be now engaged.

The utility of Geology is evinced by the zeal, with which, in different parts of the world, it is cultivated. And independent of the gratification we always feel in being able to lay open to observation the Laws of Nature, that tend only to inspire feelings of reverence and love to the great and good Being whose wisdom is so conspicuous to all, it is of the greatest practical importance to the Miner, to the Farmer, and to the Architect.

To miners, and consequently to all those manufactures connected with the metals and treasures of the earth, it offers the surest means of success, by teaching in what rock or position we may ex-

pect to find mineral treasures :—that some rocks never contain them :—that metallic substances run generally in veins, and are found only in certain rocks, and in connection with certain other substances. That coal, for instance, is never found in the primary rocks, nor in the tertiary, nor in the alluvial formations—consequently, it is found only the secondary ;—and a knowledge of this class of formations teaches us, that it is found only in the older of its series ; as with sandstone, shale, (argillaceous slate) marl, argillaceous porphyry—argillaceous iron ore ; and of these, most commonly with sandstone, shale, and puddingstone.

It teaches the agriculturalist whence to procure substances to benefit his land, and to render it fertile ; and leads him to choose such portions of soil as by their composition and associations are best fitted for his purpose.

The subject of Mineral Manures has not received in this country the attention it merits. The practical utility and value of this knowledge has been fully evinced in New-Jersey : in illustration of which I may mention a fact, which came partially within my own observation.

A few years since, the inhabitants of a small village in Monmouth county, finding that all the labour they could bestow upon their lands did not render them productive, and that they could not force "the churlish soil to yield them bread," resolved to desert the place of their nativity, and seek a more friendly soil. The discovery of marle, however, having been made, and mentioned to them, they resolved to give it a trial, and found it to succeed to admiration, and far beyond their hopes. Land that for nearly a century had been considered as without value, was soon converted into fertile fields, yielding abundant and valuable crops. The consequence has been, that the same labour which would scarcely afford subsistence, now offers wealth and contentment. The lands of the county are said to be worth at least one million of dollars more since the discovery and use of this mineral substance.

The useful operation of Draining Land, another subject of vast importance to the agriculturalist, depends in a great measure upon a proper knowlege of the structure of the Earth, and of the various strata of which it is composed; as well as their relative degrees of porosity, or capability of admitting or rejecting the passage of water through

them: and likewise the modes in which bodies of water are formed, and conducted from different elevations.

The same observations may be applied to Springs, as it is owing to these chiefly that Draining becomes necessary: and as they consist simply of water gliding along between inclined strata, it is evident, that a knowledge of these strata is essential to the detection of Springs, and their conversion to useful and ornamental purposes. Thus in some situations, Springs are only found on one side of a mountain—in other eminences occasionally on all sides of them. In searching for Springs, therefore, is it necessary to examine the strata of the country. It is only by this knowledge that we can explain the phenomena, of the different kinds of Springs:—as the perennial, that flows constantly: the temporary, flowing only at particular seasons; the intermittent, that flows and stops, then and stops flows again; the reciprocating spring, that rises and falls, or ebbs and flows at regular intervals—called also ebbing and flowing wells; of oozing and weeping Springs—and many others of this kind.

To the Architect, and to the citizen who employs him for the purposes of ornament or comfort,

this study teaches truths that are but too often forgotten. The want of attention to this subject in public works, is a matter always of deep regret. Monuments of Art—monuments intended to commemorate a great or heroic action, should be so constructed as to remain for ages the admiration of mankind: yet we often find them erected of perishable materials, and scarcely surviving the artists who constructed them.

It would not be in place to advert here to the origin of the use of stone in architecture or in statuary, nor to point out the most appropriate for those purposes. These will be hinted at in our description of Rocks, should we have time. I must observe, however, that in the erection of both public and private buildings we are lamentably deficient in respect to beauty, durability, or the interest of prosperity. We take our materials because they are near at hand, because they are cheap, and because others take the same, in preference to searching out others, which although at a distance and more expensive, are more durable and much more beautiful: which has given rise to the observation, that the ancients built, in their fullness of heart, for posterity; but that we are more selfish, and build only for ourselves.

Such was the care of the ancients to procure lasting materials for their public works, that had it not been for the unrelenting cupidity, and more than gothic barbarism of modern collectors,—more unrelenting than the destroying tooth of time, or the destruction of war,

> To rive what Goth, and Turk, and Time had spared,
> What envious Eld forebore, and Tyrants left to stand,

many Grecian and Roman temples would have remained perfect to the present day, not effected by the war of elements for more than 2000 years.

Scarcely one building in Europe or America, of modern construction, at the end of 1000 years will have one stone left upon another stone, to denote the place where it stood. And the most splendid works of modern architecture are even now hastening to decay, from want of attention to this subject. The elegant chapel of Henry VII. near Westminster Hall, in London, is an illustration of this sad truth. In the short space of 300 years, all the beautiful ornament with which the exterior was so lavishly adorned, has crumbled away. I saw the workmen, a few years since, inserting new stones on which the sculpture was copied, in place of those that were decayed; but from the same want of judgment in the choice of

materials, the present casing will not last longer than the original.

In our various excursions in the country, most, if not all of us, have observed, no doubt, that we seldom travel far over the same kind of rock; but that they usually alternate or vary.

The great rock masses or beds, are very seldom exactly horizontal, and still less often do we find them perpendicular: they all have some inclination to the horizon—thus

The angle with the horizon is called the Dip—and the edge that appear on the surface is called the Basset, or cropping out.

Upon an attentive examination of these strata we perceive that their position, their ingredients, and their associations vary materally from each other; that each has certain peculiarities of its own but that several of them have many laws in com-

mon with others, their neighbours. This has led to a division and classification of rocks, which has been variously altered and modified.

Lehman, as before stated, first divided the rocks into the older or primitive, which contain no organic remains, or petrifactions, as they are called, and into the secondary, in which he included all other rocks. A very judicious division, for the period in which it was made.

To these, as before remarked, Werner added the Transition, (or those which contain only a few organic remains) and called those secondary rocks containing many remains *Flœtz*, because he thought them horizontal. His pupils again divided this class—and made the later rocks into a new class, which they called Newest Flœtz—embracing many that are now termed Tertiary.

Another classification has been lately proposed in that excellent work "on the Geology of England and Wales," by Messrs. Conybeare and Phillips, viz. :—

Character.	*Proposed Names.*	*Wernerian Names.*	*Other Names.*
1.—Formations (chiefly of Sand and Clay) above chalk.	Superior Order.	Newest Floetz.	Tertiary Class.
2.—Comprising *a. Chalk.* *b.* Sands and Clays. *beneath the Chalk.* *c.* Calcareous Freestones (*oolites*) & Argillaceous beds. *d. New Red Sandstone, Conglomerate and Magnesian Limestone.*	Supermedial Order.	Flœtz.	Secondary Class.
3.—Carboniferous Rocks comprising *a. Coal Measures.* *b. Carboniferous Limestone.* *c. Old Red Sand Stone.*	Medial Order.	Sometimes referred to the preceding, sometimes to the succeeding class by writers of these schools—very often the coal measures are referred to the former; the subjacent limestones & sandstones to the latter	
4.—*Roofing Slate,* &c. &c., &c.	Submedial Order.	Transition Class.	Intermediate Class.
5.—*Mica Slate. Gneiss and Granite.*	Inferior Order.	Primitive Class.	Primary Class.

These divisions are the same with those generally recognised by geological writers, excepting that the 3d is by some combined with the second —by others with the fourth, but all geological analogies and relations are grossly violated by the former of these methods; and though the latter is less open to objection, yet we shall best consult that convenience to the student which it is the great object of all such arrangements to promote, by assigning to so important a series a distinct place in the general system. Different authors have as-

signed different names to these classes, from their Theoretical views: the present terms are from the fact of their relative position. Regarding the Carboniferous as the middle group, the term medial has been given to it, and super-medial to the one next above, and sub-medial to the one next below. The superior and inferior are applied to the highest and lowest series.

The terms Primary, Secondary and Tertiary are, in general, applicable to all known countries, but it does not follow that they are necessarily parts of the same formation, extending to different countries; as independent formations are numerous and extensive, and occasionally some may be wanting. Thus in many parts of our own country, the older secondary (by the pupils of Werner called Transition) is not to be found; and even on the borders of the Alleganies, can scarcely be defined. —Moreover, we are not prepared to allow in full extent the existence of universal formations. If we once admit that idea, we must acknowledge the trap of the Pallisades on the Hudson is the same as that of Edinburgh—and the coal of Lehigh and Providence a part of the bed of New Castle or of New Holland.

The Primary or Primitive Rocks are those having more or less, a crystalline texture: they contain no organic remains—and form the extremes of all series—that is to say, they are the highest as well as the lowest rocks. They are the lowest as all others rest upon them—and are the highest, because being highly inclined, and sometimes almost vertical, they rise to day at the summit of the loftiest mountains. Granite, Gneiss and Mica Slate are the most prominent of the primary class—though they by no means constitute the class as was formerly supposed.

The Allegany Mountains constitute the primitive range of the United States.

The Secondary Rocks are those lying on the Primary, usually on their declevities or at their feet. Their texture is very seldom crystalline; but more or less granular, being in a majority of cases, composed of the fragments of the older rocks, united by some cement. They contain organic remains: Their elevation is not so great as those of the preceding class.

Sandstones, Limestones and Slates are the chief members of this class. The greater part of our Western Country is of these formations. The great basin of the Mississippi may be termed Secondary.

The Tertiary Class are those of more recent origin and are all placed above the chalk. It is but a few years that these beds have been studied—but they are extremely interesting—their texure is earthy more or less—their position nearly horizontal.—Their organic remains are many and beautiful. Until lately this class has been confounded with Alluvial. Our sea-board from Martha's Vineyard, including great part of Long Island and New-Jersey—indeed all that country between the Allegany Mountains and the Ocean is Tertiary.

Alluvial beds are mostly local—and are deposits of comparatively very recent formation—indeed these deposits are constantly going on, and form one of the great changes now operating on our planet. They are composed of finer particles mostly, though not always, that are carried forward by water, and deposited mechanically—never perhaps by chemical precipitation. They are usually on plains, at the mouths of rivers, or at the margin of mountainous ridges. They consist usually of sand, clay, loam and gravel—and proceed mostly from the disintegration of rocks, by the action of running water, or of the atmosphere.—When carried forward by rivers, and deposited

at their mouths, they form sub-marine beds and islands, and eventually often fill up lakes and harbours. The sea casts up large quantities of sand, &c. increases its shore, and is gradually forced to retire before its own offspring. Girgenti, the ancient Agrigentum, in Sicily, was formerly a seaport of great consequence. When I visited these magnificent ruins, in 1819, they were more than four miles from the beach.

The extent and depth of these deposits vary, and will be spoken of more at large when treating of formations in detail.

I may remark, however, that when connected with mountains and large rivers, they often contain grains of metal, as gold, tin and iron, in such quantities as to render them worth exploring. Thus a shaft was sunk in the harbour of Falmouth, (Eng.) 50 feet through alluvial which originated in granite, and a thick bed of from 2 to 10 feet, found at the bottom, composed of round masses of tin, which produced £50,000 stg.

During the reign of Queen Elizabeth the alluvial near the Lead Hills of Scotland was washed for the purpose of finding grains of the precious metals, and 300 men were employed. The produce is stated to have been £100,000 stg.

We are not to infer from this, however, that the gold found in the sands of certain rivers has been always detached from rocks by the action of water: since the auriferous sand is frequently confined to a small district of the river—nor is it always found near to the mountains—nor is it always in level countries: The Rhine furnishes less gold at Basle than at Strasburg, much farther from the mountains whence it proceeds: and the river Tessino deposits no auriferous sand until it has passed the Lago Maggiore.

The alluvial sands of the Danube, the Rhine, the Rhone, Tagus and other European rivers afford gold—as do the alluvial of many of the rivers of Asia. The alluvial valleys or plains of Africa have long been famed for their gold dust. Our own continent is rich in golden alluvium—the gold of Mexico is found chiefly in this soil. On the coast of California are 14 leagues covered with alluvial soil, containing lumps of gold. The gold of North Carolina is also found in alluvial soil. The largest masses of alluvial gold have not exceeded 30 lbs.

The diamond, the sapphire, the ruby and the hyacinth have also been carried down by cur-

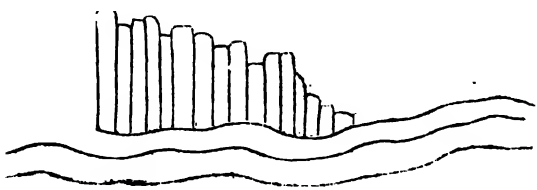
rents and found in alluvium. Organic remains are frequent in these deposits.

Formerly, as before mentioned, all Deposits were termed Alluvial, including many that are Tertiary.

But we must distinguish from these deposits, the Diluvial, a name given to those deposits which have been made by an inundation that seems to have covered all rocks, and to have deposited their debris indiscriminately, forming the last great geological change, which the surface of our Earth appears to have undergone.

The rocks included in these classes obey certain laws in their order of arrangement; and are then said to have a conformable position as seen in the figure, page 62.

Occasionally however some rocks do not obey these laws—and we find them lying on others to which they bear no relation—thus we find basalt sometimes resting on sandstone, as at the Pallisades on the Hudson—which are then said to have an unconformable position—thus



In the secondary rocks we often find pebbles, or fragments of the older rocks, consolidated into a mass by means of some cement. These are termed conglomerates or pudding stones, when the pebbles are rounded by attrition, or breccias when they are fractured and angular.

In these conglomerates we usually notice pebbles that are broken, and have their fragments near to them : but as such stones could not have been broken without violent force, their position clearly indicates that they have been subjected to such violence in or near the spot where we now observe them : Some of these broken stones do not seem to their parts near to them—thus indicating that whatever may have broken them, they have been brought here from some other spot, or else their other parts have been carried to some other place.

Some of these retain their angles so sharp as to convince us that they never could have been much tossed about—while others show us their angles and inequalities rounded off by friction in their motions. The inference is, that, the rocks whence these fragments were torn must have been solid, and exposed to violence before the beds were formed in which these fragments are found.—When such beds are not horizontal (or nearly so)

we may conclude that they are not in the position in which they were formed—but have been elevated, or depressed, by some convulsion posterior to their formation.

I have mentioned that organic remains have been found in some rocks, and not in others. As in the course of our duties this subject will often be brought to mind, I must be allowed to enlarge upon it here, in preference to calling off your attention from the rocks, which we shall describe as containing these remains of former continents and oceans.

When I say that certain shells are peculiar to certain beds, and that when in France or America we find certain shells, and know them at once to characterise certain formations of England or Germany, I do not intend to assert the universal identity of Geological formations; but to notice the remarkable uniformity of fossil conchology in certain beds.

The identity of mass and of fossils was, more than 150 years ago, insisted on by Lister: but he never dreamed of identity of mass, and diversity of petrifaction, or of diversity of mass and indentity of petrifactions; and yet he observed, that formations which were distinct by the geognosy of situ-

ation and superposition, contained in the most distant parts of the world, similar species.

Of the identity of formations, one of the strongest proof is derived from zoology, which indicates the identity of fossils in certain beds. The study of these remains is a small, but very interesting and valuable portion of the duties of the philosophical enquirer.

To distinguish the geographical limits of extinct animals and plants—to recognise the genera and species to which they may be referred—to ascertain their relations to each other—and to the classes, orders, and families of organised beings;—their numbers, as relative to the rocks in which they are found;—the progressive developement of animal nature;—to arrange species of different continents, and classify them according to zones, climates and hemispheres;—to point out the differences of fresh water and marine, of fluviatile and pelagic shells;—to note the identical species accruing in the same formation in different parts of the globe, and allow them their due weight in the determination of formations, belong to the study of Geological Zoology—a branch well deserving the attention of the philosopher.

Properly to appreciate this knowledge, it is only necessary in our researches into nature, to en-

deavour to distinguish strata which bear a resemblance to each other, by aid of their fossil contents.

In a bed of Grignon (in France) there have been found 8 species of patella and tellina—10 of venericardia and turritella; 12 of mellania and ampullaria; 15 of mitra, bulimus and cytherea; 18 of ostrea and murex, 25 of plurostoma, 33 of fusus, 60 of cerithium, and in fine, upwards of 500 different species of bivalves, besides many univalves, &c. &c.

Saussure asserts* that at Monte Bolca there are found 105 different species of fossil fish, 39 of which are said to come from the Adriatic sea, 3 from the African, 18 from those of South, and 11 from those of North America.

Dolomieu states,† as does Playfair,‡ that in every coal mine, the fern of America is blended with the palm of Africa, and the bamboo of Asia.

The clay at the Isle of Sheppey, abounding in sea shells, is reported to yield upwards of 700 varieties of fossil fruit.

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*§ 1335.

†Journ. de Phys. vol. 39.

‡Illustrations.

Fresh water shells are mixed with marine shells in several places, as near London.

The alternations of fresh and salt water productions in the Isle of Wight, and in the Basin of Paris are well known.

At Mont Matre the gypsum exhibits animals of land, air and water.* The middle beds of that rock contain fresh water shells, the upper and lower marine shells.†

At Monte Bolca, impressions of fish occur with land plants; and at Monte Pulgnasco, the bones of the elephant and rhinosceros are mingled with those of cetaceous animals.‡

Thus we see that a formation may contain, in different strata, petrifactions specifically different, but that some of the lowest stratum may be mingled with the great mass of species which occur in the superimposed strata. When these are not only specifically, but generically distinct, some being fresh water, others pelagic, it has been thought difficult to solve the unity of the formation.

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*Journ. de Phys. vol. 77, p. 362.

†Id. vol. 77, p. 365.

‡Id. vol. 39, p. 339—Vol. 66, p 105—Vol. 69, p. 81—Vol. 30, p. 50.

A large mass of marine shells may contain some fluviatile shells, or they may alternate in beds. Brongniart* and Beudant† mention the experiments made by the latter to prove how many fluviatile molusca can accustom themselves to live in the ocean. Certain species of palludinæ prefer brackish waters, and are associated sometimes with pelagic, sometimes with fluviatile shells.—Humboldt has seen crocodiles on the coast of Terra Firma advance far into the sea.‡

Relative to the distribution of organic remains, a fact has been advanced to prove that there are alternate beds of marle and gypsum, between two marine formations, containing fresh water and land productions in the centre, and marine productions above and below. This is the case (as mentioned before) with the gypsum at Mont Matre. These alternations and intermixtures in the basins of Paris and the Isle of Wight, have been attributed to alternate encroachments and retreats of the sea, and the occasional existence of fresh water lakes. The variety of species among the petrifactions, and the alternations of beds, are,

* Geogr. Min. pp. 57, 54, 89.

† Jour. de Phys. vol. 88, p. 137, 211.

‡ Eq. Reg. vol. 1, p. 535 and vol. 2, p. 606

by some, supposed to be not sufficient to sanction the idea that each bed is of a different formation, or that the beds are confused, and without Geological position. It should be observed, however, that even Messrs. Cuvier and Brongniart assign to the same formation some marine and fresh water marles and gypsums. Indeed they illustrate the term Formation by this very alternation of beds.

A difference having been noticed between fossil and the existing crustacea and other animals, naturalists were induced to examine more minutely into specific characters; and the result has been a conviction that organic remains have been deposited in successive generations, and in such order, that those of one bed bear a certain connection to each other, and exhibit peculiar distinctive points from those of earlier or of later deposit: and that the greater the distance between the different deposits, the greater the difference between the contained fossils. This deduction, combatted at first by the most learned, and ridiculed by the novi homines of science, has been found in strict conformity with the phenomena exhibited by animal or vegitable fossil remains in different parts of the world. The idea is now prevalent in Europe, and upheld by the most learned and celebrated Naturalists, that the successive generations of or-

ganised bodies that have dwelt on crust of our globe, differ from the present generations, in proportion as their remains are farther from the Earth's surface; or, in other words, in proportion as the time in which they existed is more remote from the present day.

These successive generations are discovered only in the strata forming the crust of our globe, which was composed by different operations; each possessing distinctive characters, drawn from the nature, order and structure of the rocks, and accompanying minerals. To distinguish the periods at which these different deposits have been made, is one part of Geology—and this is best and most accurately done, according to M. Brongniart, by the study of organised bodies. Even should the characters taken from the nature of the rocks, from the height of the deposit, from the scooping of vallies, the inclination of beds, and their stratafication, be at variance with that derived from organic remains, he still considers the latter as of superior validity. He illustrates his opinion by a notice of Calabria, which for 40 years has suffered the most dreadful disturbances from earthquakes: horizontal beds have become vertical: entire deposits have been transported to a distance, and have been placed unconformably (or hap hazzard)

upon other deposits; and yet these masses and deposits are never referred to different Geological periods. He fully acknowledges the force of characters drawn from the rocks themselves, but avows a preference for those drawn from the fossils they contain.

The labours of Mons. Brongniart, in addition to his advancement of the study of subterranean conchology, have served to prove the identity of some formations in Europe with some of our own country: thereby confirming more fully his opinion, that each formation has, so to speak, its own Flora or Fauna, modified by time and space.

Zoology is thus made to render a service very important to its sister Science, by the determination of relations between the formations and their fossil contents. Not only in comparing neighbouring strata, but in ascertaining those of foreign and distant countries, Zoology and Botany are themselves elevated above the mere inspection and comparison of distinctive characters, and now investigate the whole of vegitable and animal organization.

The degree of analogy or similarity between fossil and existing plants and animals is, by this extensive view, made of the utmost importance, though it may be somewhat difficult to draw the

corresponding marks and characteristics of fossil, with recent or living individuals, species and genera. This resemblance, it will be seen, leads to deductions important to a complete Theory of the Earth.

Much prudence and deep research are to be employed in the application of our attainments in Fossil Zoology and Botany: nor has this escaped the accurate and penetrating mind of the Naturalist who first established the importance of this study: thereby coinciding with the views of the deceased Werner, who never failed, in the course of his lectures, to fix the attention of his pupils on the relations that exist between certain fossils and formations of different ages.*

"I do not deny, says Mons. B. that much attention and discretion are necessary to be used in such a matter. It is requisite to distinguish and estimate even the influence of horizontal distances and of climates upon the specific differences: we must know to appreciate the apparent, sometimes even the real points of resemblance, which present themselves, in formations which are evidently very distinct, in certain species which have had the rare privilege of surviving the destruction of their

*Essai sur le Gisement des roches.

contemporaries, and of remaining always the same, in the midst of all the changes which have taken place around them. It is necessary to know, and to recognise, the individuals wrested from other deposits and transported, (by whatever causes) to new ones: and to distinguish them from those which have lived in the places and times which the species to which they belong ought to characterise. All these difficulties are to be acknowledged; and we must be on our guard against those causes of deception which introduce uncertainties in Geology, such as we meet in other sciences—and which impose upon the Geologist unremitting attention and labour, to employ with discernment the fossil and recent species whence he takes his characters, and to attach to them the true value that belongs to them in Geological researches.

In speaking of the Earth's surface, we usually divide it into Dry Land—and Bottom of the Sea.

Of the Bottom of the Sea—It was formerly supposed that fossil coal and other bituminous substances existed there in such quantity as to cause the bitterness of its waters—and Count Marsigli made many experiments to ascertain the truth of

the supposition. No experiments, however, with our present means, can be sufficiently accurate to determine this question. Since the true bottom may be, and we know often is covered by fortuitous mixtures of various substances, so as to prevent a plummet from bringing up correct proofs of its nature.

Veins of bitumen and salt doubtless continue the same, and in the same order under the sea, that we find them on the land ; and the same strata of rocks which support hills, &c. on shore, no doubt serve in the same way to support the immense mass of Ocean water. It is probable too, that the metallic and other veins existing in the Earth, run in the same manner at the bottom of the Sea. The loose particles perhaps carried off to deep water, and there deposited—but some of the veins may be exposed, and probably yield that beautiful metallic lustre, which we so frequently find on substances drawn from the depths of Ocean.

Subterranean rivers, it is probable, make great changes in the bottom of the sea. We know of the existence of subterranean currents, and the effects they sometimes produce on the surface of the globe, such as the falling in of large portions of ground—and the undermining of mountains. In the same way we know of the existence of submarine currents, which may, or may not be occasioned by the

breaking out of rivers at the bottom of the sea, and thus tend at the same time to alter the natural surface at the bottom. In clear water, near the shore, we often see these currents, and can draw up the fresh water.*

It is a pretty universal rule among those of our brethren, whose "home is on the mountain wave," the sailors, that in proportion as shores are rocky, high, and steep, so is the depth of water below them: and that low, level shores indicate shallow water. It is generally acknowledged that the deepest part of the Mediterranean is under the height of Malta—and we know that in approaching Long Island, the water is shallow. A knowledge of the strata on shore, in this way, may teach us the materials forming the bottom, as it stretches under water for some considerable distance.

It may justly be supposed that the inequalities under water are the same as those above. Capt. Cook in the Pacific, tried sounding, unsuccessfully, with 250 fathoms of line. Capt. Scoresby tried 1200 fathoms in the Arctic seas, without finding bottom. Besides a direct knowledge of the depth of water by the use of the plumb-line—and the inference drawn from the appearance of the shore, we have another criterion—I mean the thermome-

ter, to tell us when we have shoal water. This instrument shows a diminution of temperature in the water as we approach land. I dwell particularly on this fact, as it is owing to a want of knowledge of these particulars, that two fine packets in the Liverpool line have been lost within a few miles of our city, within the last eight months. Losses that may justly be attributable to ignorance—I do not say carelessness—so sure an indicator is the thermometer, in the water, of the approach of land, particularly on the East coast of the United States. I may refer for particulars to an Essay on the Natural History of the Ocean, published by Professor Silliman, in the 5th vol. of his American Journal of Science.

The coral fisheries give us occasion to discover the existence of many large submarine caverns, which, from the action of the water, are more liable to become large and empty, by the solution of mud &c., than caverns are on dry land.

From all these circumstances, in conjunction with others which it would be needless to enumerate, we have reason to conclude, that the bottom of the sea is composed of and covered by the same substances as the surface of dry land, viz. rocks, clay, sand, &c. It is in most, perhaps in all places covered with an accidental coat. In deep

water, where the surface only is agitated, the bottom is never disturbed: from such places, the plummet brings up pure white sand, or a mixture of triturated shells—or a powder formed of the fragments of coral, or parts of rocks.

The bed of ocean too has its appropriate shrubs, plants, and flowers; and no doubt the geographical distribution of submarine plants is as nicely and strictly defined as that of Alpine or other plants—and many of them are extremely beautiful.

From the depths of the sea we often draw up substances of the most brilliant colours—scarlet, vermillion, purple, blue, green, and snowy white: not superficial and transient, but in most cases real and permanent. Some marine substances, as coral, &c., do, however, exhibit on being first drawn from the water, the most superb and brilliant colours, which are evanescent, and fade in a moment. The small quantities we find on marine bodies, as we approach deep water, may give us some idea of what we might find in the deep and unfathomable recesses.

"Full many a gem of purest ray serene,
The dark unfathomed caves of ocean bear."

A poet has beautifully described a submarine scene.

It was a Garden beyond all price,
Even yet it was a place of paradise;
For where the mighty ocean could not spare,
There had he, with his own creation,
Sought to repair his work of devastation.
And here were coral bowers,
And grots of madrepores,
And banks of sponge, as soft and fair to eye
As e'er was mossy bed.
Here, too, were living flowers,
Which, like a bud compacted,
Their purple cups contracted,
And now in open blossoms spread,
Stretched like green anthers many a seeking head.
And arborets of jointed stone were there,
And plants of fibres fine, as silkworm's thread:
Yea, beautiful as mermaid's golden hair,
Upon the waves dispread:
Others, that like the broad banana growing,
Raised their long wrinkled leaves of purple hue,
Like streamers wide outflowing.
And whatsoe'er the depths of ocean hide
From human eyes, Ladurlad there espied,
Trees of the deep, and shrubs and fruits and flowers,
As fair as ours.
A silver trunk,
The fine gold net work growing out
Loose from its rugged boughs.
Tall, as the cedar of the mountain, here
Rose the gold branches, hung with emerald leaves,
Blossom'd with pearls, and rich with ruby fruit.

Dry Land is divided into Highland and Lowland. By Lowland is meant an extensive country, flat, or of inconsiderable elevation above the sea—composed mostly of plains, and hilly as it approaches the Alpine district. The few elevations that occur in it are small, and chiefly in the central part.

We have one immense tract of Lowland, traversed by the Mississippi and Missouri, bordering east on the Appalachian, and west on the Rocky Mountains.

In South America there is also one extensive district of low land, bordering on the Andes.

The principal Lowland of Europe comprises the Eastern portion of Britain and the northern part of France, the Netherlands the north of Germany and Silesia, all Poland, and the north west part of the Rusian Empire.

The central portion of Asia consists of one great Lowland Tract, called the Steppes.

The extent of this division of surface in Africa has never been ascertained.

Alpine land is composed of groups of mountains, which are again formed of mountain chains, or a series of single mountains.

Mountain groups are usually highest in the middle, and in an Alpine country each takes a differ-

ent direction, being separated by plains and vallies, or by hilly districts. Each group forms a whole, both as to base and acclivity, partially intersected in many places, but never to the base, except at the termination of the chain.

Mountainous land is composed of single mountains collected into chains, which, however, not being united by an Alpine or central chain, never form groups.

The rounded, undulating elevations of hilly districts are much lower than the preceding, and form a gradual transition to Lowland.

The summit of a mountain chain is called its ridge, and the concavities in a mountain group, which usually run parallel to its longest direction, vallies.

High mountain groups are those of an elevation of 7000 feet and upwards—as the Andes, Alps, Pyrennees, &c. Mountains of middle height, are from 4 to 6000 feet high. Low groups are from 700 to 3000 feet in height.

Generally the length of a Mountain Group is in proportion to its height, and to the breadth of its base. If the breadth and length are nearly the same, it is called Massive. If the length is considerable in proportion to its base, we say it is a long Mountain Group. Another distinction is derived

from the form and the connection of mountains composing the group, as the Common, the Alpine, and the Conic Mountain Groups.

With regard to the different parts of a Mountain, we recognise the foot, acclivity and summit. The foot is usually flat, and more or less extensive.—The acclivity is usually considered as the steepest part of the mountain, and is often almost a perpendicular precipice. The more gradual and gentle the ascent of a moutain, the more rich does it generally prove in ores.

The summit varies in steepness and shape; and the latter is indicative of the nature of the rock of which it is composed. Thus Granite and the Primary Rocks usually have sharp peaks. The elder Secondary (or Transition) are rounded: Clay and Basalt present short and obtuse conical summits.

Though Mountains are styled "La Charpente et l'Ossature du Globe Terrestre," yet the highest are but mere specks in proportion to the diameter of the Earth. Thus Mount Blanc the highest in Europe, is on the surface of our planet, what a single line would be on a globe of 21 feet diameter.

In speaking of Mountains, I must be allowed to notice a Theory accounting for their origin which has lately been proposed by a Mons. Chabrier in

a Dissertation, not long since published, on the General Deluge. Having observed the immense blocks of Granite scatterred over the North of Germany, and not being able to trace them satisfactorily (for himself) to the Mountains of Sweden or the Hartz—he wisely has concluded them to be Aerolites.—Having proved this to his own satisfaction—and having ascertained that mountains are only heaps of rubbish, he doubted if granite and the primary rocks were ever deposited from a sea which nobody had ever seen—and from other similar arguments, he asserts, that granite came, as it now exists, from the atmosphere, with the accompanying substances. This terrible shower of mountains arising from the fragments of a planetary body violently struck by a comet, rained at once upon the nucleus of ours (which gives him no con-concern) the Alps, Pyrenées and Andes and the Allegany and Rocky Mountains. The substances in falling crushed the tufted forest and produced coal by compression. The destroyed planet was that which had for its satellites the four little moons, Ceres, Pallas, Vesta and Juno, which even now irrefragibly prove the former existence of that unfortunate planet.

But even this monstrous shower of mountains does not satisfy the gentleman. It was accompa-

nied by all the waters of the planet, which falling in torrents submerged the Earth, and deluged the inhabitants: but the rain of waters preceded the rain of solids and mountains, which last came very opportunely to confine the waters, in part, and form our continents. The fossil remains of trees, of fish, and the skeleton of a man found at Guadaloupe, are the remains of the vegitable and animal kingdom of the unhappy planet.

Mons. Chabrier supposes too that some of the inhabitants of the unfortunate planet escaped the general wreck, and survived the fall, notwithstanding all this hard usage—and he thus accounts for the difference of races as observed by naturalists. Thus the Negroes and Malays are probably the decendants of the inhabitants of the other world—which at one and the same time charitably furnished us with mountains and negroes.

It seldom happens that all sides of a mountain have the same acclivity, which fact has given rise to various theories This difference was long ago observed, but it was a Swedish Naturalist who first noticed that it was so prevalent as to form a law. His observation, however, related to the extreme end only, and not to the flanks of mountains. He

stated that the steepest acclivity always faced that part of the country where the land laid highest.

Bergman observed,* that the different declivities of the flanks of mountains bear an invariable relation to their different aspects. He laid it down as a rule, that mountains running from north to south had always the west flank the steepest: and that those running east and west had always the south side the steepest.—Thus, he said, the Alps are steeper on the west and south than on the north and east, and the Cordilleras are steepest on the west.

Buffon also noticed this fact—as did Hermann, who brought as evidence the Swedish and Norwegian Mountains, the Alps, the Caucassian, the Appenines and the Ouralians.

The Carpathian Mountains, those of Norway, those on the coast of Scotland, the Welsh Mountains, those separating Saxony from Bohemia, the Hartz, the Pyrennées, and those of Crim Tartary, in Europe: The Mountains of India and of Syria, and the Cordilleras are testimonies to the truth of the observation.

I may here say that Pallas and Forster account for the unequal declevities of the north and south

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*Physic. Descript. of the Earth.

sides by the supposition of a great flood from the south, giving the Earth its present form.

The celebrated Kirwan accounted for all these inequalities by supposing a two fold violent motion of the water, by which the globe was covered : the one from north to south, the other from east to west. This last being intercepted by such mountains as run north and south, the impulse of the water was checked, and the Earthy particles held in solution by the water, were deposited on the eastern side. which thus became more gentle and moderate : while the west side could receive no such accession, and of course remained rugged and steep.—The northern current acted in a similar way, on the north side of such mountains as running east and west, intercepted its course.

It is worthy of observation, that all considerable chains of mountains run in a direction north east and south west. Our Alleganies are one proof of this remark.

Vallies, dividing Mountains and furrowing the surface, deserve the attention of the Geologist, as connected with those events that have contributed to produce the present state of our planet.

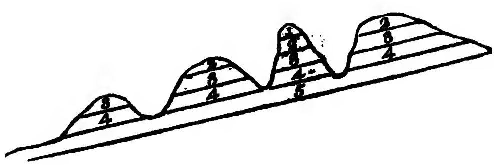
We find them commencing at great elevations, and in their course uniting in the most efficient manner to collect and carry off the water and

moisture into some large stream, on its way to the Ocean. They present such appearances as would naturally arise from water forming channels for itself in retiring from land. On a very small scale, this is daily repeated on muddy and sandy shores, when the tide is out. The present inequalities of hill and vale, afford strong reason for the supposition that it was water that produced them. We are not however to overlook the effect produced by the violent convulsions that seem to have elevated and depressed strata, in so many cases. In mountainous countries particularly, vallies seem to have owed their first outline to the disruptive forces in action around them. Instead of gentle slopes we find deep hollows, with almost perpendicular precipices, forming the receptacles of mountain lakes. Yet even these vallies have been greatly modified by water. In low countries, where no disturbance of the surface or strata exists, we must refer vallies entirely to the effects of running water. The streams however that now flow through vallies do not seem to have ever had sufficient power to form the channels in which we now find them. An eternity almost would be necessary in many cases for the present rivers to produce the vallies through which they now roll—and even then there would be physical impossibilities. What

an eternity, for instance, would be necessary for running water to produce the mountain passage of the Highlands, and wear down the solid strata of rock from the very summit of the Dunderberg to the present channel in which our own noble Hudson winds its way!

Vallies, running in the course of the mountain chains that bound them, are called Longitudinal vallies, and those dividing the mountains from each other, and cutting the mountain chain across, are named Transverse Vallies.

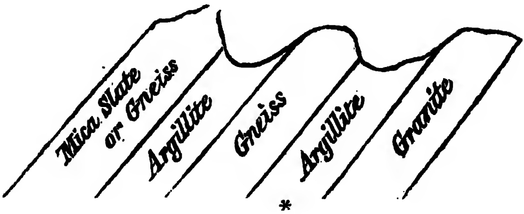
It will not be denied that vallies have been formed after the consolidation of the strata through which they run;—for we find the same strata of rocks on either side and in the same order.



This is the case in almost every valley—and it will be seen that they very generally cut the strata across.

In a few cases, however, vallies do occur between different strata, running longitudinally with

them; and then the different sides of the vallies are of course of different materials.



The cause that produced vallies has, in many places, carried off the strata that once covered masses of rock which we now find bare or insulated hills: this disrobing of the rock has been termed *Denudation.*

*It is well known that not only Argillite, but every member of the primary class has been occasionally found in contact with Granite.

LECTURE III.

Changes produced on the Earth's Surface, by the formation of Peat, &c.—of Coral Reefs—Volcanoes—Observations on their Structure, &c.—Vesuvius—Etna—Sabrina Island—Earthquakes—those of Lisbon and Calabria—Volcanic Fire—its Intensity—Situation—and Origin.

Independent of the changes that are now constantly going on by the partial agency of water, we have other causes acting more powerfully in altering the present configuration of the Earth's surface. Of these I shall briefly notice but three—viz.:

I. The formation of Peat, Bogs, and Mosses.

II. The formation of Coral Reefs—and

III. Internal Heat, as manifested by Volcanoes and Earthquakes.

The change produced by the formation of Peat is partial and trivial compared with the others.

Mountain and Marsh Peat are formed in the places whence their name is derived, by the de-

composition of plants. In the shallow parts of lakes are found numerous subaquatic plants, which in summer flower at the surface and then sink to the bottom. By the annual death of a portion of these a stratum of peat is formed at the bottom, where this process is constantly going on. The death of fresh water shell fish, and the deposits of earth and sand brought into the lake by streams, assist in raising the bottom of the lake, and thus prepare it for other plants; in like manner to thrive, blossom and die.

In other cases no distinct bed of peat is produced from the subaquatic plants—but a stratum is formed by the decay of land plants, which gradually extends into the lake and finally occupies its bed. The shells, which for centuries have been deposited at the bottom of the lake thus become covered by peat, and are eventually consolidated into marl beds—thus offering one of the most useful auxilliaries to Agriculture.

By occasional floods, sand, gravel, clay and earthy particles are thrown over these thin strata of peat, and destroy vegitation. By many and alternate similar causes, a series of beds of peat and of soil is produced, which eventually, exhausting the lake, becomes a fertile field, instead of forming a peat or moss meadow.

Different kinds of peat have their peculiar plants entering into their formation.

Mountain Peat is formed principally by the following, viz.:

Erica cinerea,	Polytrichum commune,
vulgaris,	Lycopodium clavatum,
tetralix,	Lichen rangiferinus,
Myrica gale,	Nardus strictus,
Empetrum nigrum,	Scirpus cæspitosus,
Tormentilla erecta,	Juncus squarrosus,
Arbutus uva ursi,	Many grasses of the genera,
Vaccinium vitis idæa,	Aira, agrostis, and carex.
Juniperus communis,	

In the formation of Marsh Peat, the sphagnum palustre is the chief ingredient, assisted materially however by the following, viz.:

Erica vulgaris,	Caltha palustris,
tetralix,	Hydrocotyle vulgaris,
Myrica gale,	Lysimachia tenella,
Vaccinium oxycoccos,	Menyanthes trifoliata,
Eryophorum polystachium,	Ranunculus flammula,
vaginatum,	Comarum palustre,
Schœnus albus, and others of this genus,	Narthecium ossifragum,
Scirpus cæspitosus, and others of this genus,	Pinguicula vulgaris,
Pedicularis palustris,	Drosera longifolia,
sylvatica,	anglica,
Orchis maculata,	rotundifolia,
conopsea,	Triglochin palustre,
Aira aquatica,	Phalaris arundinacea,
cæspitosa,	Arundo phragmates,
Festuca fluitans,	Juncus, many species,
	Carex, many species,
	Some of the Equiseta.

Lake Peat receives into its composition the following plants.

Conferva bullosa,	Arundo phragmates,
Lemna minor,	Subularia aquatica,
trisulca.	Lobelia dortmanna,

Nymphæa alba,
lutea,
Potamogeton natans,
heterophyllum,
and others of this genus,
Chara vulgaris,
Hippuris vulgaris,
Callitriche verna,
autumnalis,
Myriophyllum spicatum,
verticillatum,
Ceratophyllum demersum,
Utricularia vulgaris,
minor,
Sparganium natans,
erectum,
Ranunculus aquatilis,
Hydrocharis morsus ranæ,
Scirpus acicularis,
lacustris,
setaceous and others,
Isoetes lacustris,
Alisma plantago,
ranunculoides and others,
Saggittaria sagittifolia,
Butomus umbellatus,
Acorus calamus,
Phalaris Arundinacea,
Poa aquatica,
Juncus conglomeratus,
effusus, and others.
Schœnus mariscus, and others,
Menyanthes triofoliata,
Comarum palustre,
Equiseta several species.

Bogs and Mosses are also accumulations of vegitable matter in wet ground—settling in successive generations on itself, until its bulk rises considerably above the level of its bed.—The surface of a bog is always undulated, and terminates abruptly, sometimes almost perpendicularly. The average height of the great Irish bogs is about 250 feet above high water mark in Dublin harbour.

Quaking bogs are produced in wet, flat grounds, where springs abound. Weeds, shrubs, and trees, by their decay and fall, assist in daming up the stream, and the water becoming stagnant, the whole flat is overflowed. A coarse grass, which is peculiar to these bogs, springs up in tufts : the roots become closely interwoven, and in a few seasons they grow

to a considerable height. The decay of these plants in winter, furnishes soil for the reception and germination of the seeds The tops of flags and grass occasionally become intermixed and consolidated on the surface of the water, and increasing in thickness and extent, cover the superficies.—This receives seeds, which grow and cover it with vegitation, and becomes so strong as to bear a man, but still in some places trembles, or quakes, whence the name is derived.

The formation of coral reefs is daily producing a change, more or less, on that part of our globe at present covered by water, but more particularly in the Pacific Ocean. They are the production of the combined labours of millions of marine zoophytes, usually termed the connecting link between the animal and vegitable kingdoms, but perhaps more justly considered as that link between the animal and mineral kingdoms. The never ending industry of these minute animals, is supposed by many naturalists to work changes in our globe far surpassing even those produced by the fearful and powerful agency of subterranean fire by means of Volcanoes and Earthquakes.

The common foundation of all those clusters of Islands discovered in the Pacific, as well as those of New South Wales, is of coral structure; extensive reefs of which run off in all directions.

Banks of coral are found at all depths, having no communication with each other—and at all distances from land. By a rapid increase they arrive at or near the surface, when winds and waves force up loose fragments from deeper water, and, an accumulation thus going forward, islands are seen in all the different stages of progressive formation—as shoals first—then as reefs or breakers—eventually as bare rock above the water, and finally in their state of perfection. covered with soil, and adorned in all the beauties of vegitation.

Kotzebue in his voyage to the Pacific, and Capt. Flinders, in his account of New South Wales, have each given many pages to these interesting productions.

It seems probable that when these little animals have commenced their labours, and have ceased to live, their structures adhere together—and the small interstices being filled with sand, a solid rock is soon the consequence. Future races continue to erect their habitation on the rising bank, and die in turn, while elevating this monument of their labours. It is by a surprising instinct that in

the early stages of their labour, they work perpendicularly; and as they erect their wall chiefly in situations where the winds are constant, they thus afford a shelter to the leeward, whence their infant colonies are sent off. It is owing to this that the windward side of a reef of coral is always the highest part, rising sometimes perpendicularly from the depth of 200 feet, or perhaps as many fathoms.

It seems necessary to our busy labourers to be covered with water, in order that their work may be uninterrupted, for as soon as the reef has reached such a height as to remain almost dry at low water, at the time of ebb, the corals cease to build higher; sea-shells, fragments of corals, echinæ and their broken off prickles become united by the burning sun, through the medium of the cementing calcareous sand which has arisen from the pulverization of the shells, into one whole or solid stone; and this, strengthened by the continual throwing up of new materials, gradually increases in thickness, till at last, it becomes so high as only to be covered by the high tides of particular seasons.—The solar rays so heat this mass when it is dry, that it splits and breaks off into flakes. These flakes are again thrown upon each other at high tides. The active surf throws blocks of coral

(sometimes 6 or 8 feet long and 3 or 4 thick) and shells of marine animals between and upon the foundation stones: after this the calcareous sand lies undisturbed, and offers to the seeds of plants and trees cast upon it by the waves, a soil, upon which they rapidly grow to overshadow its dazzling white surface. Entire trunks of trees, carried by rivers from other countries and islands, find here, at length, an accidental resting place. With these come some small animals, as lizards and insects, as the first inhabitants. The sea bird nestles there, and by feathers, &c. contributes to the formation of a soil—sea plants now take root upon it—a cocoa nut is cast on shore—stray land birds find it a refuge—the seeds of shrubs and trees are thus carried there, and when the work has long been completed, man also appears, builds his hut on the fruitful soil formed by the corruption of the leaves of the trees, and styles himself lord and proprietor of this new creation.

But of all the changes arising from causes now in actual operation, those resulting from the agency of Subterranean Heat, by Volcanoes and Earthquakes, are the most remarkable and interesting. The time allotted allows me to cast but a cur-

sory glance at a few of the facts in connection with these phenomena, which often in a few minutes change the whole surface of a country.

In the earlier periods of our globe, these fires seem to have been more extensively in action than at present; as is proved by the many remains of extinct volcanoes of great size which we find in various parts of the world, and by the existence of rocks nearly allied to volcanic products in almost every country.

Of the structure of these mountains, I shall only say that they are generally truncated cones, with an aperture in the centre, called the Crater, whence the eruptions issue: but not unfrequently they break out at the side or foot of the mountains; and occasionally under the sea—and are then termed Submarine Volcanoes, or Eruptions.

Most of them are situated near the Ocean, or to Lakes, whence many Geologists have supposed that water forms one of the chief agents in volcanic phenomena.

When single, they have a pyramidal or conical form, ascending at a moderate angle of inclination from the base to an elevated plain, from the centre of which rises the principal Crater.

No burning Volcano situated in a chain of mountains is to be found in Europe or Asia—they be-

ing generally at a distance from them. On the American Continent, on the contrary, Volcanoes of the most stupendous size form part of the Cordilleras. In the south of the province of Quito, in Chili, and in Guatimala, they are grouped in rows.

Baron Humboldt—than whom no man has ever visited a greater number, or drawn more philosophical deductions, in regard to them, has made the following observations, viz.

1. That Mountains with slender conical peaks have eruptions of the greatest violence and at the shortest intervals—as Cotopaxi, Peak of Teneriffe, and Orizava in Mexico.

2. Those with long summits, rugged and rocky, are nearly extinguished—as Hecla in Iceland, and many in South America.

3. That rounded summits indicate in many places porphyritic lava, that has been heated and raised up, but never burst forth as Chimborazo, and the greater Sarcony in Auvergne.

All Volcanic Mountains have the cone, or sugar loaf, as it is appropriately called, covered with scoriæ, or cinders and ashes. I myself believe that the whole cone is composed of such substances as have been ejected once, at least, those nearest the heat being again consolidated. It has been usual for travellers to state, that from the brim of

the crater, it was easy to see the boiling lava within. This good fortune did not attend me, as I found it not only dangerous, but impossible to get within such distance of the crater of Vesuvius, during an eruption, as to allow the angle of vision to be more than 45°. But even had it been possible to stand on the very rim of the crater, and cast the eye directly downwards, the thick cloud of smoke hanging within, would have concealed the burning mass.

The shape of the crater is constantly varying with every new eruption. Its size does not depend on the elevation or mass of the Volcanic Mountain. Vesuvius is a small hill compared with the Peak of Teneriffe, and it has a crater five times larger. The Volcanoes of the Andes have all small openings, and there are many reasons for believing, that the size of the opening diminishes as the elevation of the mountain is greater, were it not that those of Cotopaxi and Rucipichinca have craters three fourths of a mile in diameter.

The depth of a crater varies continually in active volcanoes; but in those long dormant, it undergoes no change excepting that produced by the occasional fall of part of its wall. In this case it allows of actual measurement: thus the crater of the Peak of Teneriffe is 105 feet deep.

The whole cone of a Volcano is sometimes swallowed up during an eruption, leaving a larger circular crater, at a less elevation, which finally becomes dormant, and forms a Lake. Such is the celebrated Lake of Avernus, and that of Agnano, near Naples.

Independent of the destructive changes produced by the burning lava, and by the scoriæ falling in showers around the crater whole mountains are sometimes formed at one eruption; thus Monte Nuovo about 10 miles from Naples was raised in one night; and Monte Rosso on Etna, with a base of 2 miles in circumference, and a height of 750 feet, is composed of the scoriæ that fell after one eruption of 1569. The color of the mass of materials of this last mountain is generally reddish, as the name denotes, and the scoriæ contains embeded schorl.

In the intendancy of Valladolid, in New Spain, is an immense plain belong to the plantation Jorullo, 2600 feet above the sea, and cultivated during the last century with cane and indigo, having its elevations crowned with evergreen oaks, and palm trees. After some admonitory warnings, a tract of ground, in this place, to the extent of 10 miles, rose in the shape of a bladder, being about 40 feet at the edges, and 534 feet at the centre

above its former level. Many mountains soon after rose on different parts of it, the most elevated of which is the Volcano Jorullo.

There are other proofs of the reason we have to consider internal heat as an active agent in the production of Geological phenomena : but these will suffice.

I have abstained from entering into minutiæ concerning any one volcano. Having visited some of the most celebrated in Europe, I may perhaps be indulged, at the risk of an imputation of egotism, in briefly relating a few particulars.

In 1819, I had the satisfaction of seeing and of visiting Vesuvius during an eruption. The darkness of the night, the time I had chosen, (for my first visit) rendered the scene more awful and sublime. In ascending the cone, we traversed beds of lava that but a few days before had been vomited forth: Although the surface was black, the interior was still a heated mass ; and we saw the yet red lava through the small cracks in the surface. On inserting through these fissures the sticks we had in our hands, they were immediately withdrawn on fire. We could not approach within 6 feet of the rim of the crater, and even by crawling could not get our faces near the edge, so as to see the bottom—or indeed any thing but a mass of cloud ob-

structing the sight. The dreadful bellowing and roaring of the interior was indeed awful, and at intervals a sudden and tremendous explosion warned us of the shower of stones, that ascending in the flames, were to fall red hot around us. These stones were of all sizes, and we endeavored to escape the shower by running down the cone.

About 100 feet below the brim of the crater, through a hole in its side, gushed a constant stream of liquid lava. It appeared of the consistency of molten iron, and flowed slowly in the channel it had formed for itself. From this liquid mass we contrived, by the aid of poles, to detach small masses, in which we inserted each some small article, while the lava was pliable. Some silver that I had in my pocket, and my watch key, were among the articles thus forced into the liquid lava, which then cooled around them: as you now see them.

Having retired about 100 yards from this burning river, and thrown aside some of the smaller cinders so as to form a small excavation on the spot where a current of heated air was escaping, which served to keep us warm, we took our supper, and lighting our torches by the lava, wrote letters to our friends—and then slept, for an hour, before the glorious orb of day, rejoicing in the east, called us to the summit to behold its splendor.

There are 36 eruptions of Vesuvius on record previous to 1806, since when they have been almost annual. The bed of lava runs for many miles, and often, as you are all aware, destroys towns and cities.

——— Villages, and woods and rocks
Fall flat before its sweep.—The region round,
Where myrtle walks, and groves of golden fruit
Rose fair ; where harvest waved in all its pride ;
And where the vineyard spread its purple store,
Maturing into nectar ; now despoiled
Of herb, leaf, fruit and flower, from end to end,
Lies buried under fire, a glowing sea !

Mount Etna, in Sicily, had been long dormant, when in 1819, I visited that volcano. Monti Gibello, or Monte Bello, (from Mongibello, *Mount of Mounts*) as it is called by the inhabitants, has been so often visited and described, that it is needless, nor would it be proper, for me, here, to enter into a detail of its history or its beauties. Relative to its history, it may be observed, that doubts have arisen as to its origin; which shall be spoken of in another place; here it is only necessary to observe that Count Borch, and some other Geologists consider Etna as a Granitic Mountain, containing abundance of lead and copper, merely covered by volcanic products. In proof of which, it is alleged, that on the mountain shells exist at the

height of 2000 feet above the sea—and that strata of clay with marine shells are found 2400 feet above the sea, dipping towards it; and which probably had been formed there while the mountain was progressively rising from the ocean. But I consider Etna as an assemblage of mountains, piled on each other, and which have been produced by different eruptions from many volcanic openings, most of which are now dormant; and that the whole mass is thus an accumulation of volcanic products. Monte Nuovo and nearly fifty other mountains on that side of Etna next to Catania are formed wholly of ejected substances.—Many of them are now covered by a fertile soil, though still exhibiting the crater well defined.

After leaving the luxuriant and fertile region that skirts the base of the mountain, and forced our mules over the sterile band, near to the regions of eternal snow, we passed this frozen zone on foot, and reached the cone, which we ascended. The lower half was covered with snow. The upper portion, nearly half a mile, was clear to the brim of the crater. From the surface of this brim or edge, which was hot to the feet, arose heated air, strongly impregnated with sulphur. As this air or gas oozed through the surface it deposited beautiful and brilliant crystals of sulphur. On

breaking up the crust with our sticks, we saw them glistening, and collected quantities of them: some of which are now on this table.

The interior of the crater was covered with snow near the bottom;—except the northern side, which rose a solid wall, separating it from another crater. From cracks in this wall, and from a few small openings in the bottom, a thin white smoke was gently ascending, and, in small quantity, gracefully curling itself into the atmosphere.

We descended some distance into the crater, in pursuit of specimens of the many crystals known to exist among the products of this volcano.

It was a mild and lovely evening, when, after having been refreshed at St. Nicoloso, we continued our way to the summit, so as to be there by sun-rise. I only mention this to add that during our ascent, we found it extremely cold before we reached the frozen region—and that we beheld at the same time a thunder storm some distance at sea. On leaving the summit for our descent, we experienced all the vicissitudes of climate, extreme cold, a snow storm, and several violent showers of rain, with alternate intervals of a scorching and brilliant sunshine.

We are all aware of the distance often run by the lava from this volcano. Catania, nearly 40

miles from its summit, has often been destroyed by it. Taormina, about the same distance on another side of the mountain, has often suffered the same fate. In its vicinity is found a beautiful red lava.

The base of Etna covers a circumference of about 36 miles; and on its sides are not fewer than 80 cities, towns, and villages, and allowing from 1200 to 1500 persons to each, it may be safely stated that there are 100,000 people inhabiting voluntarily the crust of this immense volcano.

One of the latest submarine volcanoes of which we have an account, was that, which, in 1811, burst forth in the Azores, near St. Michaels.

Immense clouds of black smoke were observed to rise from the surface of the sea, when, suddenly a column of cinders, ashes, and stones shot up with great violence, accompanied by a grumbling noise and vivid flashes of lightning.

The depth of water at the spot was formerly 180 feet. The quantity of ashes and scoriæ was so great that on the fourth day the accumulation was seen to rise above the water, forming the rim of the crater, which thus was reared among the waves.

The island of *Sabrina*, thus formed, rose about 250 feet from the sea, with a circumference of about a mile, at the waters edge.

A similar island arose many years since, near to Tercira, of the same group, in a single night.

The islands that have been produced by submarine volcanoes in the Grecian Archipelago, are among the most remarkable products of these phenomena.

We all know that volcanoes eject many substances beside lava—and that cinders and ashes are sometimes projected to a great distance. The celebrated Pompeia, which has so often been described by other persons who have visited the interesting ruins, was covered by ashes showered upon it from Vesuvius, (from which it is distant about 12 miles) in the year 79 of the Christian era.

Intimately connected with the preceding phenomena, both as to cause and effect, is that dreadful convulsion of nature, for which no word in any language has yet been found to convey an idea sufficiently appalling. No word can impress upon the mind the terror it occasions. The extensive, immediate, and awful consequences of the earthquake, leave no hope, no refuge for the alarmed individual—no refuge but the refuge of despair.

There is no country that is not more or less affected by them: even the sea is subject to them.

The annals of the world mark no week, perhaps no day, that is not a record of their devastation —No accurate account of the cause of earthquakes has been handed to us by preceeding philosophers. All their investigations ended in supposition, instead of collection, comparison, and reflection.

One of the earliest earthquakes on record since the Christian era, was that which, under Tiberius, destroyed in one night 12 cities in Asia Minor, in a circumference of about 300 miles in diameter. It is remarkable that no other changes took place—no springs or fountains were dried up, the course of no river altered—no hill overthrown—but all remains the same at the present day.

The history of the violent earthquakes that in the sixty third and succeeding years of our era, preceded those eruptions of Vesuvius, which destroyed Herculaneum and Pompeia, and in which the elder Pliny lost his life, is familiar to most of us.

During that fearful one which preceded the eruption of Vesuvius on Sept. 28, 1538, the Lucrine lake near Naples was lost—a whole town and all its inhabitants swallowed—a tract of ground near Lake Avernus rose up, and in one night Monte

Nuovo (formerly mentioned) arose, and next morning showed an elevation of 1127 feet above the level of the sea. The whole country was destroyed, and in 24 hours not even the vestige of a habitation was to be discerned.

The famous Earthquake of 1755 that destroyed Lisbon, and that which in 1783 convulsed Calabria, are the most important on modern records. A mere outline of either would occupy an hour.

Of the violence of the former we may form some idea, when we know that it was severely felt over all Spain—(except Catalonia, Arragon, and Valencia) —that in Africa it was almost as severe as in Europe—that it was felt in England, Scotland, Norway, Sweden, Germany, Holland, Switzerland and Corsica—even in Antigua and Barbadoes—nay, even on the shores of Lake Ontario. At Lisbon it began 25 minutes past 9 in the morning. Between 9 and 10 the master of a vessel bound to the West Indies, being then in north lat. 25, and west long. 40, and many miles from land, heard a violent noise, and perceived his ship agitated as if by a sudden jerk—He started in great terror, and perceived through the cabin window land at the distance of about a mile, which, when he got on deck, had disappeared. In another minute three rocky pinnacles rose from the sea and spouted wa-

ter, and a heavy dense cloud, which ascended, and left no trace of the rocks. Another vessel, between 9 and 10 the same morning, about 40 leagues from St. Vincent, was violently jerked, as if she had struck a rock, and all hands on board were thrown down. The sea was agitated for a minute, and then no trace of rock or storm appeared.

The Earthquakes of Calabria were equally awful. Kircher, who witnessed one in 1638, published a long and interesting account of it. Sir William Hamilton has given a valuable and accurate statement of the convulsions of this unhappy country, from which it appears, that in one year, 1783, it suffered from 949 Earthquakes.

Their effects are still visible: I have witnessed some of them with an anxiety of mind not to be imagined. The ordinary action of the elements can never efface them. It can only be effected by some convulsion even more terrible than its predecessors.

It will easily be imagined that as Heat is the prime agent of one of the prevalent Geological theories, and is so intimately connected with Volcanoes and Earthquakes, that many disputes have arisen on the subject. They may however be

reduced to three, viz.—as to the Intensity, the Situation, and the Origin of Volcanic Fire.

Messrs. Le Sage and Deluc, and afterwards Dolomieu, made a series of experiments on Lava, which was found to vitrify more completely in furnaces than in volcanoes; and many crystals that were embedded in it were easily fused; whence they concluded that volcanic fire was not so very intense, and that its effects were caused, rather by extension and duration, than by activity. Sir Jas. Hall overthrew the force of these experiments as far as vitrification was concerned; inasmuch as vitrification, according to his experiments, does not depend so much on the degree of heat, as on the rapid cooling of the stone or lava.

He was further confirmed by the valuable experiments of Mr. Watt, proving that if the process of cooling be very slow indeed, a crystalline arrangement of the particles is the consequence.

Observations, made by men who are capable of judging, are far more important and conclusive than any experiments; and from a comparison of these we are entitled to conclude, that sometimes the heat of volcanoes exceeds that of the most powerful artificial furnaces: but that the fluidity and heat of lava does not always indicate such intense heat.. Spallanzani passed a current of lava upon Et-

na, that flowed 11 months previously and which was still red hot at some distance beneath the surface. The Abbe Ferrara mentions that when in 1709 they opened at Catania the current which flowed from Monte Rosso 40 years before, flames broke forth, and the retained heat was so great even at the beginning of this century, that rain, when it fell upon it, passed off immediately in vapour.

Upon opening some houses in Torre del Greco, nearly buried in the lava of Vesuvius in 1794, iron utensils were found partially volatilized, and some crystals of iron (specular) discovered on the surface.

We know on the other hand that many crystals, easily fusible by the blow pipe, are ejected unaltered by volcanoes. In the list of substances vomited forth, we find many that were, and many that were not fused. Here is a specimen that sets all caballing at rest—a piece of lime, with an embedded shell, sent forth during an eruption of Vesuvius, and presented to me by Sig. Monticelli, so well known as having indefatigably studied this volcano for many years.

As to the *Situation* of volcanic fire, viz. whether it originates in the mountain itself, or is placed at a great depth below the surface: It has been supposed that volcanoes originally break out in

mountains already formed, and merely cover them with lava and scoriæ. For instance, that Vesuvius and Etna were always mountains, either primary or secondary, and that volcanic fire has only altered their forms perhaps, and covered the surface with lava, &c. On the other hand, it is asserted that these mountains are entirely produced by subterranean heat, and composed of the lava and scoriæ thrown up—as the Monte Rosso (already noticed) and Monte Nuovo, near Naples: or else that they have been raised by subterranean heat, which has softened and elevated the strata above it, as mentioned in the tract of land in South America, and on this a volcanic crater had been formed similar to the Jorullo.

To a calm and unimpassioned man, to the philosopher, both of these views will appear nearly correct. There can be no doubt that Monte Rosso, Monte Nuovo and Jorullo were formed by eruptions even had we not the testimony of witnesses; and we are justified in concluding that the source of the heat was far below the base of these hills. But there are many other volcanoes, to which such origin cannot be attributed. On Etna, for instance, we find calcareous strata, with imbedded remains of shell fish resting on beds of volcanic tufa, and dipping to the sea. Here the inference is plausible,

that the first eruption took place beneath the sea, and that the strata with marine organic remains were deposited before the mountain rose from the ocean. In fine, that the volcano existed before the mountain—that its first eruption was submarine, and the whole masses subsequently elevated, or the sea depressed. The same may be said of the Peak of Teneriffe and of the Canary Islands. There is a great difference between the elevating and breaking up of strata, and the mere accumulation of lava and scoriæ, of which the celebrated Island Sabrina was formed in 1811 off St. Michaels in the Azores. It is proved by both phenomena that the location of volcanic fire is far below the surface. Were it placed in the mountain itself, we cannot conceive why, after burning 1000 years, the walls do not fall in; and when once extinguished it would be very strange that it should occur again in precisely the same spot.

The supposition of the School of Werner, that volcanic fire is seated in coal beds, is very inadequate :—the depth would not be great enough for the production of the consequences—the sides here too would fall in; and why, when once burned out, and extinct for 700 years and upwards, should

it break forth again in the same place? A coal pit near New-Castle (upon Tyne) took fire in 1648, and burned for 40 years, when it was extinguished, without a sign of volcanic fire.

Some philosophers have supposed that fire existed universally in the bowels of the Earth, and that the contact of water with it produced steam, the immediate cause of Earthquakes, which, when it found an opening, was expelled in the form of an eruption. Thus, they say, the Earthquakes of Calabria and Sicily were always accompanied by eruptions of Vesuvius or Etna: thus, during the Earthquakes, formerly mentioned, of Lisbon, fire was seen to rise in the middle of the Atlantic: thus the Earthquakes of New Andalusia and the West Indies are connected with the volcanoes of the Andes: thus, when Caraccas was destroyed in 1812, St. Vincent, dormant for 100 years, broke out afresh. The night when Callao and Lima were destroyed, four new volcanoes appeared on the Andes. All these circumstances probably gave rise to the opinion prevalent among the vulgar in some parts of the world, that the interior of our globe is the Devil's workshop, to which volcanoes are the chimnies. The bottom of the Mediterranean between Sicily, the Lipari Islands and Naples, is covered with volcanic substances; and Humboldt considers

the Mountains of Quito, 700 square leagues, in extent, one immense volcano, throwing out flames at different cones.

The *Origin* of volcanic fire was formerly attributed to fermentation below the surface, which was not only explained and illustrated, but a recipe for making them composed.

If any of you wish for a volcano on a small scale in your garden, take 25 lb. of powered sulphur, and as much iron filings, mix them into a paste with water and place the whole in a large iron pot, covered with a cloth, some little distance under ground. In a few hours, from 9 to 12, the earth swells, heats and cracks—hot sulphurous vapours arise, and the cracks enlarging, a brilliant flame bursts up, thus forming a volcano in miniature spontaneously produced by the reciprocal action of water, iron and sulphur. Thus spontaneous combustion was supposed to arise from the contact of water with iron pyrites, which contains both iron and sulphur. A district in Dorsetshire (Eng.) abounding in pyrites, after a heavy rain, in a hot summer, took fire and burned for a long time.

Sulphur and Bitumen have been supposed to give rise to volcanic phenomena; but though sulphur always is, bitumen has never been found in

volcanic products. Monticelli has lately detected free sulphuric acid, an important discovery.

The true cause of volcanic fire is probably not to be sought for in the combustion of such inflammables as we find on the surface of our globe; but in the chemical combination of elementary matter composing mineral substances.

The existence of volcanic fire, then, is proved by the fact itself, as appearing in volcanoes; the connection of volcanoes with each other, and with earthquakes, proves its situation to be very far below the surface; the original cause of this fire, and the reason of its breaking out occasionally with greater violence, are among those mysteries which still continue to elude our grasp—and will probably remain forever hidden from the knowledge of mortals.

LECTURE IV.

Minerals entering into the composition of Rocks—Different forms of Rocks—Masses, Beds, Strata, Nodules, Veins—Internal Structure of Rocks—Laminar, Fibrous, Spheroidal, Prismatic, Veined, Cavernous, Amygdaloidal, Aggregate, Granular, Porphyritic—Texture—Fracture—Hardness—Color—Frangibility—Lustre—Transparency—Specific Gravity—Action of Acids.

Having cursorily glanced at the present appearance of our globe, and at the changes now going forward, from various causes, on its surface, we proceed to examine the rocks that enter into its composition. Before entering upon a description of them, it is necessary, however, to premise that a knowledge of Mineralogy is in some degree essential to the study of Geology, of which it has been not unaptly styled the Alphabet. Nearly all mineral substances are found either as constituents of rocks, or as occasional substances imbedded in them.

There are not many minerals entering into the composition of rocks: The following enumeration

is perhaps complete. For a knowledge of these substances I must refer you to some treatise on mineralogy—and none is more deserving of commendation than that of Professor Cleveland, of Bowdoin College.

Clinkstone,
Compact Felspar,
Quartz,
Felspar,
Carbonate of Lime,
Mica,
Chlorite,
Talc.
Hornblende,
Actynolite,
Augite,
Serpentine,
Steatite,
Noble Serpentine
Gypsum,
Iron,
Bitumen,
Pitchstone.
Chert.

A larger number of substances occur imbedded in rocks, in such quantities as materially to alter the character of the matrices, viz.

Garnet,
Olivin,
Cyanite,
Pinite,
Spodumene,
Chiastolite,
Staurotide,
Epitode,
Mesotype,
Zircon,
Topaz,
Beryl,
Chrysoberyl,
Fluate of Lime,
Corundum,
Oxydulous iron,
Pyrites,
Chromat of iron,
Prehnite,
Andalusite,
Apatite,
Sphene,
Oxyde of tin,
Molybdena.

It is not too much to say that every variety of mineral is found imbedded in, or connected with some rock.

Rocks in different positions assume different forms ; which may be reduced to five, viz.

IRREGULAR MASSES,	NODULES,
BEDS,	VEINS,
STRATA,	

Irregular Masses, may be of any size ; and often constitute mountains, as is the case with granite, serpentine, porphyry, and the overlying rocks, as trap, &c.

Beds are of various sizes ; often running into irregular masses : They are straight, or curved, and frequently intersected by joints, so as to assume a cuboidal appearance. Few rocks assume this form : those most disposed to it are granite, porphyry, syenite, and greenstone or hornblende. This distinction is considered, by Dr. Macculloch, as being practically the most easy, and perhaps the only one necessary for the student. Beds and irregular masses often give out veins that penetrate the adjoining rocks.

Strata have been confounded with beds, but they are generally much larger, and usually are more extensive in two dimensions than in the third : so that strata may be considered as immense beds with the upper and lower surfaces parallel, in most

cases; but occasionally meeting at a very acute angle. Strata do not necessarily preserve the same thickness, and often vary in the course of a few yards; nor are they always straight; frequently being contorted and flexed into larger or smaller curvatures, which may be either parallel or transverse to the plane of stratafication.

This form of rocks is of various extent, sometimes being discernible only for a few hundred yards, and at others being well defined for hundreds of miles. Strata are found at all angles with the horizon, and in all relative positions to each other and the adjoining rocks.

A rock is not necessarily of the same modification through the whole extent of a stratum, as the texture may vary to the widest limits of fine and coarse.

Strata never send off veins into adjoining rocks.

Nodules, or imbedded irregular masses, is a term lately adopted to include rocks which are not stratafied nor disposed in pseudo strata (beds), and which do not resemble in their connections other large irregular masses. The forms of the Nodules are various; and they are usually imbedded in the stratafied rocks; but occasionally in granite. The size varies from a foot to a mile. Limestone.

Serpentine and compact Felspar alone have been found of this rare division of form.

Veins are known by their filamentary forms, and by intersecting all other forms of rocks and each other. As this is an important subject and one that has given rise to much Geological disputation, it may be well to enlarge upon it; premising that the school of which Hutton was the founder, consider veins to have been filled from beneath by the action of fire: while the disciples of Werner maintain that they were filled from above by aqueous solution and infiltration: all acknowledging that they occupy places or fissures originally open.

Veins are simple, or they exhibit branches or ramifications: the latter are more generally met with in Granite.

The size of veins varies from a mere thread to several hundred feet in breadth, being smallest usually in the primary rocks, and from one foot to several miles in length.

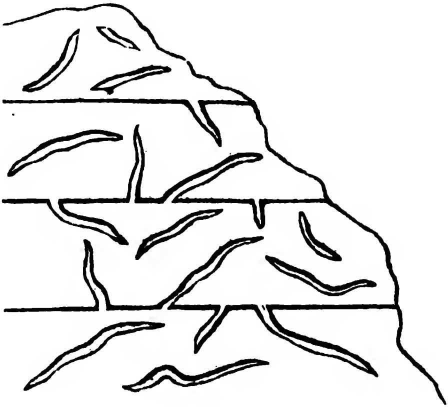
The relative position of veins is extremely diversified, intersecting rocks in all directions, forming every possible angle with the horizon, and dipping to every point of the compass: the course of a vein being straight or flexed.

It has been observed that veins, except those of quartz and calcareous spar, are limited to granite and the overlying family, or the traps, syenite, and porphyry.

Rock veins are often traced to some irregular mass, though not in all instances. They may traverse several different formations, and are always different from the rocks they traverse.

Contemporaneous veins differ from true veins in many particulars. The breadth is seldom more than a few inches, the length varying from half a foot to more than an hundred feet. The course is scarcely ever straight; and they give off many branches. They are usually intimately connected with the walls of the rocks in which they occur—sometimes passing into them insensibly differing but little in composition, and often being one of the constituents. Thus granite contains contemporaneous veins of quartz, of felspar, and of mica. Gneiss affords them of the same substances. Mica slate, into the composition of which felspar does not enter, contains veins of quartz, and of mica, and of the two variously blended.—They never traverse more than one bed or stratum, and have no connection with any other mass of the same substance. They seem to

have been formed at the same time with the rock in which they are found.



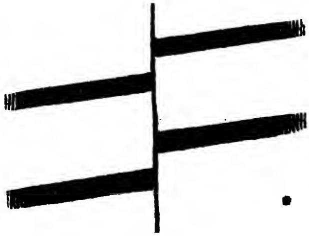
The walls of a vein are the sides of the rock containing it, being in many cases the sides of the fissure. The upper and lower walls are called roof and floor, or pavement. The sides of many veins are usually marked by thin layers of some argillaceous substance.

Veins often intersect each other, and in some cases have a regular structure, being filled with different substances observing a parallelism and the same order from both walls to the centre.

Cross courses are veins not being metalliferous intersecting metallic veins.

Sometimes the body of a vein and the surrounding strata seem to have been fractured, and part

of it to have fallen down, leaving the edges no longer in continuity: this is called a shift of the strata—thus:



Internal Structure.

The Internal Structure and the Texture of Rocks have been recently divided, and treated of separately: the following are the different varieties of structure.

Laminar: which may be divided into the lamellar, foliated and schistose.

In the former division of this structure, a rock divides more or less easily into plates, seldom continuous or allowing further division.

The lamellæ are not necessarily straight, and occur from a few lines to many yards in thickness. They are sometimes divided by natural joints, and then assume a prismatic a cuboidal figure.

There is a large and a small lamellar structure: the former is seen in granite, the latter in horn-

blende. This structure occurs in masses and veins.

The foliated structure occurs in the mixed rocks only, and is defined to be "rather a tendency to split into parallel laminæ, or an appearance of parallelism in the disposition of the integrant minerals, than in the property of actual splitting."

The laminæ are irregular, and often curved: as is usually seen in foliated rocks. They are seldom continuous or even; when they are, the structure is passing into the schistose.

The schistose structure is evinced by the fisility of the rock on the use of force: being rarely affected by the weather; while foliated and lamellar rocks are.

This modification of structure is found in simple as well as aggregate rocks. The thickness of the laminæ is inconsiderable; the length varies from half an inch to several yards. They are sometimes even and smooth, at others rough and nodular. They are not necessarily straight.

This structure occurs only in strata.

The schistose sometimes run into the next division of structure.

Fibrous is confined to argillite and limestone. It is sometimes parellel, straight or curved. The fibres sometimes diverge, presenting a ramified appearance.

Spheroidal comprises all varieties of concretionary structure. The concretions may be spherical, touching only at points, the interstices being filled. At times, by compression, they become ovate, and assume irregular shapes. Sometimes they have a radiated structure; and sometimes contain a nucleus. In some cases this structure is observable only when the rock is weathered.

The size of the concretions seldom exceeds an inch and is at times very minute.

In some cases this structure is confined to spots in the rock, and then the concretions are large and irregular.

Prismatic, including columnar structures. The common prismatic is a modification of the large laminar, divided transversely by natural joints: being cuboidal or quadrilateral, seldom having a less number of sides.

By the action of weather, or by partial decomposition the angles are often rounded, so as to present a spheroidal concretionary structure:. which is also caused by the desquamation of crusts.

In columnar structure there is no limit to the number of sides, and the length is much more than the breadth. In such instances as exhibit a very short prism, the structure becomes tabular. This structure is always aggregated. No instance having occurred of a single column.

The prisms are often seen in parallel ranges forming a bed for some distance; and sometimes pass imperceptibly into the massive rock. When parallel and upright, their beauty and regularity is remarkable, and has given eclat to "Fingals Cave" in the island of Staffa. Parallelim is not necessary; since they are sometimes found diverging as from a centre; occasionally in confused heaps, and again dispersed and entangled, as it were, in the massive or amorphous variety. Nor are columns always straight; being sometimes much bent in the same direction, or in contrary directions, or mixed with straight ones.

The prismatic structure occurs in veins as well as beds. It does not necessarily exclude the smaller kinds of structure, as the amygdaloidal and porphyritic.

The size of prisms varies from an inch or less, in diameter, to several feet: in basalt they occur occasionally 9 feet thick, in iron stone sometimes the tenth of an inch. In length from 1 to 300 feet—or perhaps more. They occur with all number of sides from 3 to 12.

Prisms are usually divided by irregular joints, destroying the appearance of continuity. The most perfect and numerous joints are seen in the most regular columns. Occasionally they are so frequent

as to produce tabular prisms. The surfaces of these joints are in close contact—and may be plane or concave and convex, presenting a ball and socket joint.

Veined, comprises all those veins confined to one rock, and which consist of the same substance as the matrix. One or more veins may be found separate, or confused in the mass—and occasionally the same appearance presented by the veins is observable in a patch or spot at a distance from it. The size of such veins differs from half an inch to a few feet—both in length and breadth. Their hardness usually resists decomposition, and causes them to be raised above the surface. Sometimes they are discernible on the fresh fracture, at other times not till the matrix is in part worn away. They often intersect each other, exhibiting a reticulated surface, showing that in the interior of the rocks laminæ cross each other. Trap and granite are more frequently veined than other rocks.

Cavernous. When in the last mentioned structure, the intervening walls or veins no longer appear small, but constitute the greatest portion, it passes into the cavernous, which is seldom seen on the fresh fracture; but frequently when the surface is partially decomposed. The cells vary in size, shape and frequency—and are often filled with

some substance different from the constituents of the rock. This structure is often seen in sandstones and limestones.

Amygdaloidal and the preceding are often found in the same rock. The caverns or cells are filled with different mineral substances, appearing to be imbedded. These vary in size and shape.

This structure is mostly confined to the overlying family, and to rocks of volcanic origin.

Aggregate evinces a composition of the fragments of different rocks—as the breccias and conglomerates and sandstones. The parts consist of one or more rocks, with quartz—united sometimes with, and sometimes without, any apparent cement: the size varying from a grain to several feet. The fragments may be rounded or angular—sometimes, but rarely, both are found in the same mass.

Granular, also called crystalline, exhibits grains of one or different minerals closely aggregated, as if by confused crystallization, usually of small size.—It is difficult to be distinguished from the last variety.

Porphyritic, where crystals of one or more minerals are included in a simple or compound base. The size of the crystals varies from a mere speck to an inch, or more. When the crystals disappear, or the base is coarse granular, the structure changes. It is connected with the amygdaloidal.

Texture.

Under this term are arranged those modifications in which the mass appears homogeneous, or consisting of parts that cannot be separated.

It is in this way distinguishable from structure, in which we see the component parts more or less separated: so that the texture is in fact indicative of the structure. In mineralogy the term is familiar. It is not seen, except the rock be broken; and most of the circumstances arranged under this head are also embraced by the terms fracture and structure.

Granular does not denote that the rock may be separated into grains: but is applied to its aspect. This texture is not always the same. It is sandy or arenacious, or is flat. The appearance may be crystalline, or earthly. It passes into the crystalline, and fibrous and scaly textures.

Bladed. I do not remember to have seen this texture. It occurs in hornblende and actynolite schists, and arises from the interlacing of prisms, passing from the granular texture to the fibrous.

Fibrous, arising from the condensed aggregation of minute irregular prisms, more or less distinct.

The fibres are not always straight: but may be curved, or radiating, or confused, for which modi-

fications several names have been given, indicative of the arrangement.

By the parallel position of minute scaly or granular particles, it passes into the scaly texture.

Scaly, in which the scales may be parallel or confused, and more or less easily separated.—Usually the scales are minute; when not, this texture passes into the small lamellar structure.

Compact texture presents no appearance of grains, and is considered as precluding all the preceding modifications. The various aspects it assumes belong to the succeeding character.

Fracture.

By this term is understood the appearance of a new surface of a rock, upon being broken. It depends in a great degree upon the texture; the small fracture more particularly. There are several modifications of fracture.

Even; in which the surface is a plane, without, or with a very small degree of curvature.

Uneven: in which the planes are variously inclined, and form by their angles, elevations and depressions. When minutely uneven, with the elevations and depressions considerable, it becomes granular, and forms a texture.

Conchoidal. In this fracture one surface is concave, and the other convex, to a greater or less extent, and frequently marked by curved lines, more or less parallel.

There are several accidental varieties of this fracture: two distinct concavities may occur, the smaller within the larger, or there may be several small conchoidal appearances producing an undulating surface.

These three varieties may be united, or pass into each other. They may also be united with some of those that follow.

Splintery, is produced by wedge shaped scales, straight or curved, of which the thin edges are more or less elevated, and occasionally transparent.

In the large splintery fracture, the scales are of considerable breadth in proportion to their thickness, and are flat or curved. It occurs frequently in connection with the choncoidal.

In the small, when the splinters are very narrow, they may exhibit something of a fibrous aspect:—when thick and short, something of a granular appearance.

Hackly fracture is rare—occurring only in some schistose rocks. It is known by the extreme sharp-

ness of the protruding parts. It may be well seen by the transverse fracture of aggregated fibres.

The *granular*, *fibrous*, and *scaly* fractures are similar to the textures with those names.

Hardness.

This character of rocks is so various that it is impossible accurately to describe it. It ranges from the hardness of quartz to that of chalk.—These extremes are well known, and the intermediate varieties must be tested by some equally known standard; as the comparative ease with which they are scratched by the point of a knife, or the finger nail. To strike fire with steel is an inadequate test, as that depends often on the form of the fragments, and is frequently produced by the intermixture of quartz.

Colour.

Among the external characters of rocks none varies so much as colour—and still it has often been insisted upon as characteristic.

In some instances the colour is well defined, as in limestone, serpentine, &c.—but in many cases the tints are broken; and those comprised under the ceaseless changes of grey are the most predominant. Different colors are sometimes present

in the same compound rock: and occasionally depending on the colour of several substances united in the mass.

Iron, in some of its conditions, is usually the agent by which rocks are coloured.

The endless variety of colours affords a name for every shade which may be found in rocks—but as the colour of the same rock frequently changes, this character does not belong to the permanent catalogue. Still it merits attention, as frequently forming species which in economical purposes are highly prized—as in marbles.

Mr. Symes of Edinbugh has published a work on colours wich deserves notice by those who wish more particularly to attend to this character of rocks or minerals.

Frangibility.

This character is very various, as some rocks yield to a slight blow, and others resist a great force. It depends in some measure upon the water the rock contains, and the direction given to the applied force. When the interior of a mass is broken it is often frangible for the time, but becomes tough by exposure. To convey the proper idea of the frangibility of a rock, it must be compared to some familiar object,

Lustre.

This character varies from that of plubmago, the highest degree of lustre found in rocks, to that of chalk, which is dull and earthy; in fact to the total want of lustre. The shades are not very numerous, and are often indefinite. The standard however being fixed, a reference is easy and sufficiently definite for common use; thus there are six degrees of lustre referred to, viz: the plumbaginous, the silky, the resinous, the vitreous, the flinty, and the waxy. The latter offers a double standard of comparison, in its lustre, after having been melted, and in the fracture it presents when broken.

Transparency.

The thin edge of a splinter of rock may transmit a small degree of light, and be translucent, but although transparency belongs to several minerals, it does not properly appertain to rocks.

Specific gravity.

This character is of little or no value in the comparison of rocks. When the weight of a rock is mentioned, the specific gravity ascertained in the usual mode, should be noted, so as to convey a definite idea.

Action of Acids.

In discriminating certain limestones, the action of dilute nitrous or muriatic acid, by the extrication of carbonic acid gas, is a convenient standard.

LECTURE V.

Primary Rocks—Granite—Gneiss—Mica Slate—Argillite—Serpentine—Limestone—Quartz rock—Chlorite Schist—Talcose Schist—Hornblende rocks—Actynolite Schist—Porphyry—Syenite. Identity of formations—Isochronism—Alternation—Loxodromism—Character of Primary Soils.

All geologists agree in assigning an extreme date to GRANITE—and it is usually placed as the first, or lowest of primary, and therefore of all rocks. It is considered as unstratified: is one of the most abundant, and most useful of rocks. It derives its name from its usual granular appearance.

It is placed in irregular masses beneath all other strata, occasionally sending veins into the adjacent rocks. It seldom presents a definite form: but is occasionally so divided by fissures as to make it bear some analogy to stratification. When these crevices or fissures are so placed as to produce a prismatic figure, the angles are sometimes rounded off, and an irregular spheroid is the result.

Granite sometimes presented a minute, but irregular prismatic structure, independant of the above.

It is also occasionally minutely laminar, or exfo-liates in crusts, that are sometimes concentric, sometimes flat; in some cases appearing the result of a concretionary structure in the rocks; in others as the consequence of atmospheric action.

The component parts of Granite are Quartz Mica and Felspar: of these three substances I shall give a brief notice—not intending it however as a precedent to be followed in describing the other rocks: but to show the necessity for an intimate acquaintance with mineralogy, previous to commencing the study of Geology. It will also show the connection between mineralogy and chemistry.

Quartz is a siliceous earth very plentifully distributed. It is frequently limpid, but occurs of all the tints of yellow, green, and red, derived from metallic agents.

Its usual form is a 6 sided prism, terminated by 6 sided pyramids, more or less regular. Not unfrequently it has metallic fibres running through it, and then becoming more valuable, is cut and set as an ornament. It has a great comparative hardness, scratches and cuts glass; and is not scratched by steel. Before the compound blowpipe it melts instantly...

Quartz is the purest variety of siliceous earth. containing about 69, and some even 96 per cent. of pure silex. Rock crystal is quartz. It forms a large proportion in the composition of calcedony, agates, flints, jaspers &c. It is also a constituent in many gems: Opal and Cairngoram are nearly pure quartz. Topaz, Hyacinth, schorl, and tourmaline, aventurine, emerald, beryl and garnet all contain large portions of this earth. It is an important article in the arts; is used in the manufacture of glass, is an ingredient in the preparation of porcelain, and earthenware, and of smalt. It is used in the form of sand, in all mortars—and in agriculture, for the improvement of certain soils.

Felspar is also widely distributed. It is a compound substance, in which silliceous earth is in the greatest proportion, frequently coloured by oxide of iron. The following is the composition according to

	Chenevix.	Brande.
Silex - - -	64.	68.
Alumine ·	24.	20.
Potash - - -		8. 50
Lime - - - -	6. 25	2.
Oxide of iron - -	2.	.50
	96. 25	99

It is softer than quartz, and easily fusible. It is usually red, grey, or white, with varieties. The crystals are 4 and 6 sided prisms, bevelled, the primitive form being a slightly obtuse rhomboid.

The extreme beauty of some varieties of feldspar has occasioned its use in ornamental jewelry. Persia, Arabia and Ceylon furnish the green variety, which is much prized. On the coast of Labrador it occurs very beautiful. To Dr. Bigsby, we are indebted for the knowledge of an extensive locality in the vicinity of Lake Huron.

Under the name of Petunze, it is used in the manufactory of porcelain—It was first employed by the Chinese:—is now extensively used by the French at the celebrated Sévres, under the name of decomposed feldspar—and also by the English, who have a valuable locality of it in Cornwall. It retains its whiteness remarkably pure, from there being no iron in its composition. By analysis it yielded according to

Vauquelin.		Wedgewood.	
Silex	74.		20.
Alumine	14. 05		60.
Lime	5. 05	Loss and moisture	20.
	95.		100

The other ingredient usually noticed is *Mica*—a compound mineral, consisting of the earths, silex, alumine, and magnesia. tinged with iron. Its color is grey, passing into brown and black —very rarely, green and rose coloured. It is easily fusible by the blowpipe. Its crystal is a rhomboidal prism; —texture lamellar; It is easily divisible into extremely thin plates. It is scratched by the finger nail. It yields by analysis—

Silex	-	-	-	48. 0
Alumine	-	-	-	34. 25
Potash	-	-	-	8. 75
Ox of iron		-	-	4. 50
Maganese	-	-	-	0. 50
Water	-	-	-	1. 25
				97. 25

In Siberia and Russia this mineral is reguarly mined and is an article of commerce, under the name of Muscovy glass. Its flexibility has caused its use instead of glass, in the Russian ships of war, as it is not liable to breakage by the discharge of guns. Considerable quantities are exported:—200 puds being yearly sent to Lubec, and a large quantity to England and Ireland.

These three substances, quartz, felspar and mica, are usually considered as the component parts of Granite, and so they are, generally. But it is a distinction not sufficiently correct for geological

purposes. For instance, in a small space, either the former or latter of these may disappear —and the latter invariably does in graphic granite. Hornblende is sometimes a constituent, with all the other three—and sometimes usurps the place of mica insensibly, and forms a compound of quartz, felspar and hornblende; which is then called Syenite.

Granite therefore consits of quartz, felspar, mica and hornblende in different proportions. Other minerals too sometimes enter into the compound—viz: actynolite, chlorite, talc, compact felspar and steatite.

The size of the grains of granite varies from a minute speck to several feet in length. It is so fine as scarcely to be distinguished from sandstone, and so coarse as to be almost a conglomerate; and these gradations may occur almost imperceptibly in a short distance. In one locality alone, Corsica, it is orbicular.

The proportions of the ingredients vary much: generally speaking felspar is the most, and mica the least abundant. One of them, the quartz particularly, may be altogether wanting—and in some cases one of them may form large masses or beds.

The colours of granite are of almost every shade —that of the felspar, as it is the most variable, and abundant, usually regulates the general tint of the rock—Dark red, yellow—and all varieties of gray —to black and green.

Quartz is next in quantity, and its whiteness assists in forming the general hue of the granite—it is sometimes grey, smoky, and black.

Mica being either white, or brownish, or blackish, modifies the colors of the compound—causing grey and black tints, which may also arise from hornblende. This mineral however, being almost constantly blackish or dark green, contributes in proportion to its quantity.

Sometimes each of the minerals may have a different color—and occasionally, though rarely, all may be crystallised.

The size and position of the different ingredients have given rise to several varieties.

Graphic Granite, is composed chiefly of quartz and felspar, the latter forming a broad base, in which the other is imbedded: when broken across the rows of quartz, it resembles written characters, and hence the name. Its decomposition furnishes porcelain clay—Kaolin. It is found on our own Island.

Globular Granite is composed of distinct concretions. The most beautiful is from Corsica and Arran: not found in this country.

Porphyritic Granite is so called from the fineness of its texture, which contains large crystals of felspar.

Protogine arises from the substitution of talc, steatite or chlorite for mica—al ogether or partially.

Owing to the want of uniformity in the proportions of the compound, granite has received new and various names: thus when only two of the usual constituents are present, imbedding some other simple mineral, it was called a Granitic aggregate.—Kirwan introduced specific names for these aggregates; they have however been abolished.

Granite, I have said is the oldest rock. It occurs in mountain masses—and apparently, in strata, in veins, and in beds. It does not seem to have been deposited at the same time. It forms the highest as well as the lowest points that have been examined, and constitutes the summit and central part of the highest mountains. In some instances it is entirely hidden by the rocks superimposed.—When it forms the tops of mountains, the summit presents a ragged and pointed peak. The highest locality in the world where granite has been been seen—indeed the highest rock that has been,

examined is on the summit of Mount Blanc, or rather a few feet below the summit, whence I brought these specimens in 1819: they are of the variety protogine.

Mount Blanc in Savoy is the loftiest mountain in Europe, rearing its majestic head 15,680 feet above the level of the sea: being three times higher than the highest point in the United States.

The relative height of Mount Blanc is greater than that of Chimborazo, since it rises 11,530 feet above the valley of Chamouny, while Chimborazo is elevated but 11,232 feet above the valley of Tapia, making a difference of 300 feet relative height. The upper $\frac{2}{3}$ of this mountain of granite are within the confines of perpetual snow. Rising above the clouds, its summit enjoys the golden splendour of the sun, but is cheered by no plant nor animal.

But seven times since its creation had the summit been trodden by the foot of man previous to 1819, when I succeeded, in company with Dr Howard, of Baltimore, and nine guides, in an attempt to reach the highest point of Europe. After a journey of 53 hours, 45 of which were passed in the region of eternal ice, we returned to the beautiful vale of Chamouny. As our perilous and fatigueing expedition, unfortunately added no scientific ob-

servations to those made by Saussure and others, we abstained from obtruding on the public the recital of our dangers or sufferings.

Many beautiful and valuable minerals occur in granite, as

Garnet	Apatite	Actynolite
Cyanite	Pinite	Gabbronite
Spodumene	Idocrase	Wernerite
Corundum	Anthophyllite	Pyrites
Beryl	Andalusite	Oxidulous iron
Emerald	Stilbite	Sphene
Topaz	Jade	Oxide of Tin
Chrysoberyl	Fetstein	Lapes Lazuli
Epidote	Tourmaline	Graphite
Zircon	Schorl	
Fluor spar	Tremolite	

Many metals are found in granite—either in beds, or in veins, or disseminated through the mass—viz: Tin, iron, tungsten molybdena, uranium, titanium, manganese, arsenic, cobalt, zinc, lead, bismuth, copper, silver and gold.

Granite contains neither coal, gypsum or salt.

It is the most durable of all rocks, and, as it can be worked and polished, it is well suited for architecture. The columns of the portico of the Pantheon, the Ionic columns of the temple of Concord in the Forum Romanum, and many others, as well as the obelisks, in Rome, are of granite brought from Egypt.

Gneiss which is generally placed second on the list of rocks, is also a compound of quartz. felspár and mica. Its structure is usually slaty, while granite is granular and this is supposed to constitute the sole or surely the chief difference. It contains more mica and less feldspar than granite. The mica forms fluillets or small leaves between the quartz and felspar—and when Gneiss is divided, it facilitates the operation by its want of adhesion, and shows itself in more abundance.

The composition always, and the texture often assimilates this rock to granite. The following are the points of distinction. Crystals of mica and hornblende in granite are mixed with the utmost irregularity, but they preserve a paralell in Gneiss, giving to it the foliated aspect. To describe the modes of aggregation would be to repeat what has been said of Granite.

In some countries it is the most abundant of the primary rocks, forming whole districts and constituting high mountains of one entire mass. Its strata are of various dimensions, generally thick, unless alternating with quartz rock, mica slate. or hornblende schist. when it becomes thin: particularly when alternating with latter stratum.

Gneiss is not always perceptibly stratified: when intersected by veins of granite, it has many resemblances to an irregular granitic mass: when the grains are very coarse, the resemblance to granite is so strong as to confound the student. This is more especially the case when the veins of granite, run parallel with the laminæ.

When there is no intermixture of granite veins the stratification of gneiss is very regular.

Gneiss is subject to contortions of all magnitudes. It offers so many varieties of structure as not to allow of specific descriptions: the granitic, the schistose and the laminar are usually noticed.

Where gneiss and granite are in immediate contact, the transition is scarcely perceptible by the variety, magnitude and mixture of the particles, until at length the fissile or foliated structure becomes apparent.

It is the next rock to granite, and occurs resting or lying upon it. When they are both seen in the same mountain, its ledge is always the lower of the two. Mountains of Gneiss are seldom so steep as those of granite, and the summits are not quite so peaked.

Gneiss, like granite, has been formed at different times—and is found alternating with granite, with serpentine, and with mica slate.

The colour of gneiss varies in the same manner, and from the same cause, as that of granite.

It is the repository of many minerals—of which the most usual are

Sapphire,	Epidote	Carb. of Lime
Ruby	Garnet	Tourmaline
Emerald	Actinolite	Melanite
Beryl	Quartz	Idocrase
Cats eye	Feldspar	Oxydulous iron
Zircon	Hornblende	Cinnamon Stone
Chrysoberyl	Fluor Spar	

It also contains beds of limestone, hornblende, porphyry, and anthracite.

It is the most metalliferous of all rocks—containing all those found in the preceding in greater quantity—In Norway, Sweden, and Saxony, the most important mines are in this rock.

It is used for the same purposes as granite, but is neither so durable, nor so easily cut and polished.

Like its predecessors, Gneiss becomes irregular in composition; varying from the older kinds, in which the component parts may be said to be disposed into distinct curvilinear layers, to the newest varieties, where the composition becomes more diffused, and the layers thinner, the structure perfectly slaty, and the whole mass more fissile, when it passes into the third primitive rock.

Mica Slate: composed of quartz and mica, variously mixed, the latter usually predominating. It differs from Gneiss principally in wanting feldspar as an ingredient—and as the same ingredients constitute Quartz rock, it passes into that also. It also passes easily into Chlorite Slate and Talcose Slate, and occasionally even into Argillaceous Slate, so much is its character sometimes modified by the admission of these minerals. The colour is usally grey, derived from the shade of the mica, as the quartz is almost always devoid of color. It may be altered by the admission of foreign substances into its composi'ion. It is brilliant—but easily decomposes. The older varieties sometimes contain felspar.

Like other primitive rocks, it appears to have been formed at different periods.

The strata are sometimes very thick, so as almost to seem unstratified. It is more slàty than gneiss, and the layers not always straight—often flexed into contortions, sometimes without affecting the stratum. It is occasionally split into plates or slates. It is not decided if the laminar structure is or is not parallel to the plane of stratification.

The position of this rock varies—as it alternates with granite, gneiss and greenstone slate, indeed sometimes with argillite and limestone. Its usual place is on gneiss covering granite. It generally forms large tracts of countries. and elevated mountains, seldom high cliffs; the hills are roundded at the summit, and are in long and beautiful ridges, separated by moderate vallies.

It is remarked that this rock supplies the greatest quanties of crystallised minerals—among these are.

Garnet	Actynolite	Pynite
Tourmaline	Epidote	Oxydulous iron
Beryl	Andalusite	Pyrites
Schorl	Kyanite	Staurotide
Emerald	Phrenite	
Corundum	Apatite	

It sometimes contains beds of limestone, serpentine, hornblende, quartz, &c.

It abounds in ores, in beds and veins, more particularly the latter. The mines of Saxony, Bohemia, Hungary, of Delicarlia and Fahlun are in mica slate.

It will have been observed that mica slate and gneiss are nearly allied to granite, and it was formerly supposed that the three constituted the primary class, and formed the primitive ridges of countries. I have mentioned they are the oldest rock

and form the highest mountains. They are widely distributed. No country is without them, though they may not always predominate.

Where the laminæ allow mica slate to split into large tables, it is useful for fences and for many domestic purposes.

The origin of granite has been a subject of warm discussion to those geologists who regard theory as the most important part of the study—and it has received different explanations from the different schools.

The Wernerians regard it as a deposition from aqueous solution, which was followed by the other rocks of the same class. They account for granitic veins by a new deposition entering crevices and fissures of the original strata.

These granite veins are supposed by the Huttonians, on the contrary, to have been elevated by some power below; so that granite is the latest, instead of the earliest rock, has been consolidated by heat, after the other depositions were made, and forced up so as to be elevated, with all the other strata resting upon it, to an inclined and even vertical position.

This explanation does not agree with the locality of many veins that can not be traced to any original mass or mountain—of which kind many exist.

The elevating by these means of such immense masses of granite as mount Blanc and Chimborazo appear scarcely credible.

As Geology became a subject of study and attention, it was found that the three rocks already mentioned, by no means constituted even the greater number of the primary class. The most important addition was Argillaceous Schist or ARGILLITE: important for many reasons. It was originally considered as appertaining to the next class of rocks, and by being introduced here blends the Primary and Transition—as even those sections of Argillite which are termed primitive are allowed to pass imperceptibly into the transition. On this account the arrangement of Macculloch seems highly proper—and I shall follow him in placing under this head "all those schistose argillaceous rocks, of the primary class, (in which he includes the old transition,) however differing in texture; thus comprising the clay slate and the graywacke of some geologists." His reasons are sound, so far as my observation or reflection goes.

In all cases, the coarser and finer varieties of this rock occur as parts of one series, however the one or the other variety may predominate in particular instances. If fine beds or strata are found without the coarser, or if the later are found

without the finer, it offers no greater reason for their separation than is offered for a similar division of gneiss or mica slate by its coarse or fine textures. These textures too occassionally present themselves in the same bed, either laterally or transversely. Moreover, in the case of sandstone this arrangement is adopted for similar reasons, no distinction being made between the fine and coarse varieties, although the differences of conglomerates and fine sandstones are much greater than is ever met in Argillite. And why should not strata, mechanically recomposed, be found among the primary, as well as among other rocks.

The only differences that have ever been offered between the older and newer varieties of this rock, are negative. Such as the absence of nodules or compact limestone, in the former; the want of chiastolite, of numerous beds of greenstone, of alum slate and drawing slate—and even these characters are so dubious that the most experienced geologist may be at a loss, as Argillite frequently shows all varieties in a small space.

The essential components of Argillite are the peculiar indurated clay which alone forms all the simple varieties, with mica and quartz—The coarse varieties, or greywackes, contain also primitive fragments: felspar is sometimes found in it, giving it

a porphyritic appearance. These circumstances produce different kinds of texture: the finer is compact and uniform: other varieties occur from the mixture of sand, gravel and mica. In the older kinds, the mica is in large scales and assimilates it to mica slate, while in the newer the mica becomes very small and fine. In the compact varieties as hone slates &c. the union of parts is too firm to be a mere mechanical adhesion: but generally indurated clay is the cement.

It passes into siliceous schist and into sandstone.

Argillite sometimes composes whole countries, but is occasionally only in small quantities, alternating with other rocks in a very curious way.

On this continent it is found supporting immense countries, as all the table land of St. Fee de Bogota—in Peru it rests immediately on ancient granite. Indeed the gradations are insensible of granite, gneiss, mica slate and argillite.—Thus a large country exhibits gneiss constantly alternating between granite and mica slate: and mica slate between granite and clay slate, whence some geologists have been desirous of joining them as one formation: in the same manner that syenite and serpentine pass into that greenstone called

transition. In Cornwall it rests near to granite.— In England it occupies large tracts, and is followed in order by the secondary rocks.

Although it may be difficult to trace the outline of the beds, the stratafication of argillite is not disputed. In large tracts it is frequently of immense thickness; but in alternations it becomes very thin, in the same manner as micaceous schist: and in the same way too the strata are liable to contortions, but seldom the rock itself.

The schistose structure of this rock renders it valuable for many purposes, since it can be split into lamina of almost any thickness, particularly the finer varieties; though often the graywacke schists are divisible to the same extent. This tendency is not necessarily, though it is generally parallel to the plane of stratafication: it is sometimes oblique, but never in the secondary slates.— The finer varieties present sometimes a fibrous structure.

Natural joints are sometimes transverse or oblique to the plane of stratafication, forming rhomboidal or prismatic figures, more or less perfect. Most frequently the intersections are made by minute and numerous veins of quartz or calcareous

spar, which in some rare cases follow the contortions of the schist.

The following minerals occur in this rock.

Garnet	Wavellite	Lazulite
Epidote	Staurotide	Tremolite
Topaz	Andalusite	Stilbite
Opal	Chiastolite	Oxydulous iron
Cyanite	Brown spar	Pyrites
Chlorite	Calc. spar	

Argillite contains numerous ores—the hills of Lima and Potosi, rich in metals, are of this rock—The copper and tin mines of Cornwall are in argillite.

It contains beds of graphic and chlorite slates, of talc, hornblende, greenstone, novaculite.

It has a few organic remains: which offer the only strong reason why this rock should not be classed among the prim.ary

It is abundant in this state. Large quantities of it are annually brought from Rensselaer county to Albany and to this city. In the counties of Ulster and Dutchess it occurs of such quality as to be worked advantageously.

Pennsylvania possesses it in Wayne county, in Lancaster and in York, extending into Maryland. These quarries yield annually about 1600 tons—worth 22 Dollars a ton.

It occurs near New Haven in Connecticut and is extensively quarried at Charlestown, Mass.

It has been traced by Dr. James and Mr. Eaton about 30 miles on the Hudson. In the United States it has an extent of about 400 miles North and South.

The acclivities of Argillite are not very steep—and the soil yielded by its decomposition is better than what is generally afforded by the primary rocks.

These four rocks form the great divisions of the primary class–but do not constitute it, as there are many other important members of this series, which were formerly treated of as subordinate beds.—Divisions in all branches of science are readily made, but distinctions not so easily. In considering them as distinct formations I am borne out by the result of the observations of Humboldt and Macculloch—and no other authority need be cited. The short portion of time allotted for this course allows of no discussions, nor would they be profitable. I shall therefore proceed to an account of the other members of the primary family. Some of them are indeed very small, but not less important in a geological point of view.

Serpentine, is a beautiful rock presenting some shade of green mixed with white, yellow, brown or

red; and its name has been derived from the fanciful arrangement of the colors, bearing some resemblance to the skin of a serpent.

Its surface is glossy, though dull, and offers to the finger that saponaceous feeling, so peculiar to all magnesian rocks and minerals, indicating the presence of Magnesia.

It seems to hold the first place among these less extensive members of the primary class in any arrangement founded on the age of rocks, as it is not unfrequently found resting immediately on granite.

It does not appear to be stratified, nor is there any reason for supposing it to be so. It differs from all unstratified rocks in having no veins running into the neighbouring strata. In Aberdeenshire it is included in granite; but in Great Britain it occurs mostly among gneiss, argillite, hornblende rocks and limestone, and occasionally in mica slate. It rests, forming the chief component of whitestone, on ancient granite, in the Erzeberg. It is occasionally covered by gneiss and sometimes by mica slate. A small formation of it in Saxony rests on gneiss, and is not covered by any other rock. In S°. America, on the mountains of Higuerote, it occurs in a similar position. The large formations of this rock are posterior to argillite.

With whatever rock Serpentine may be connected, it forms intimate associations. When in con-

tact with limestone, the two rocks frequently blend. A gradation may be sometimes traced from serpentine to hornblende, to which it is intimately connected. It has been observed that when veins of trap pass through secondary limestone, it is converted into serpentine during its passage, and by an interchange of the imbedded minerals belonging to either, a gradation may be established between trap and limestone.

It is sometimes connected with carbonate of lime, and thus forms the beautiful marble called verde antique.

The texture varies from highly crystalline to compact and earthy. It is susceptible of a polish, and is highly prized. The precious serpentine is in small quantities, and is very beautiful.

Serpentine is the repository of many imbedded minerals, some of which occur in such quantities as materially to alter its character. The list follows:

Asbestos	Tremolite	Chrysolite
Amianthus	Talc	Opal
Steatite	Jade	Chromate of iron
Diallage	Pyrope	Oxydulous iron
Hornblende	Calc. Spar	Lithomarge
Actynolite	Idocrase	
Quartz	Garnets	

It is seldom the gangue of metals—In Cornwall it is blended with native copper, and in Piedmont it is associated with beds of magnetic iron.

It is not an uncommon rock in Europe. It forms the top of Monte Rosa, and of Pindus—and of the Appenines generally.

In this country it forms an insulated mass at Hoboken. At Rye, W. Chester, it occurs, and will receive a good polish. Near New Haven it is found with large beds of lime stone, and is quarried extensively. At Westfield (Mass.) it is enclosed in granite, in very small quantites.

Primary Limestone is a very interesting rock, of which our information is not very accurate. It is only by a close examination of the geological position that it can be known—as it bears a strong resemblance to the secondary marbles—and more particularly to that portion usually called Transition, and thus offers another argument to Dr. Macculloch for his wishing to embrace this latter class in the Primary Rocks—It is a remarkable rock, composed almost entirely of calcareous matter.

The colours are so various as scarcely to be subject of definition They are usually derived from inflammable matter, from a mixture of other substances—or from iron. The most esteemed is the white, which bears a fine polish, and is sometimes translucent.

It has been used for centuries for ornamental purposes in sculpture and architecture. Many of the noblest monuments of Grecian artists are in marble.

The white marble of the Alps and of the Vallais is highly prized. The grand cathedral of Milan is built of primary marble from the Lago Maggiore, as well as the suberb triumphal arch of Napoleon, which his spiritless successor has left unfinished—a monument of his illiberality and want of taste.

I shall briefly notice a few of the more valuable and rare antique and modern marbles; though this belongs more particularly to mineralogy.

The Parian marble of the ancients was snow white, with the slightest possible tinge of yellow, the grain fine, and when polished the appearance was somewhat waxy. By exposure to air it hardened, and thus resisted decomposition for centuries. It receives the most delicate touches of the chisel, and retains them for ages, with all the softness of wax and the mild lustre of the original polish. The finest Grecian sculpture that has descended to us, is in this marble. The Venus di Medici—the Venus of the capitol—the Diana Venatrix—the Colossal Minerva, the recumbent Ariadne—Juno Capitolina, and Diana and the Stag, in the Louvre, are all formed of this marble.

The Pentelic marble, from mount Pentelicus, near Athens, closely resembles the preceding—but is more compact and of a finer grain. When the Arts, at a very early period, had attained their full splendor in the age of Pericles, the Grecians prefered this marble to the Parian, probably because it was nearer. The Parthenon was built entirely of it—as were many Athenian works, erected during the administration of Pericles, as the superb temple of Ceres, or Eleusis.

Among other beautiful relics are the torso of the Belvidere—and the muses of the Vatican—and in Paris, a Bacchus in repose—the throne of Saturn—and the tripod of Apollo. It was remarked by Dr Clark that while the works executed in Parian marble remain perfect, those finished in the pentelic marble have been decomposed.

The marmo greco was obtained from Scio and Samos, in the Archipelago.

The white marble of Luni on the coast of Tuscany takes so fine a polish and so delicate a touch that the Grecian artists latterly prefered it to all others. The Antinous of the Capitol is of this marble, and the Apollo Belvidere, "the statue that entranced the world."

The white marble of Carrara is of this formation. The quarry was first opened by Julius Cæsar and it has ever since been highly prized.

Foreign marbles were introduced to a great extent among the Romans. Pliny, who wrote 166 years after the first importation of marbles, remarks the rapid progress that had taken place in that period, from a simple and unadorned way of life to magnificence and extravagant expense. In the reign of Diocletian, 240 years afterwards, the importation of foreign marbles was discontinued, as the columns employed in the baths of Diocletian were taken from more ancient buildings. The large and superb obelisk in the Circus Maximus of Rome, was brought to the city after this period however. Its removal from Egypt was began by Constantine, and finished by his son. For removeing this, it may be remarked, the largest wrought stone ever moved in Europe, there existed sufficient mechanical skill at that period, although the arts connected with design had considerably declined.

The white marble of mount Hymmetus in Greece —the translucent white marble or Marmo Statuario of the Italians—the flexible white marble.—the roso antico—the verde antico—the giallo antico—the antique cipolin and the antique african

breccia are among the ancient marbles of this formation.

The red and white Tiree marbles, the Iona marble and the marble of Skye, and many others of Scotland—The Mona marble of Anglesea—and the black marble of England; the Waterford, and the Tipperary and the Kerry marbles of Ireland—the Languedoc and Campan of France—the Sienna—the mandelato—the green marble of Florence—the Verdi di Prado—the Rovigo—the Luni -the Venetian—the Laggo Maggiora, the Bretonico --and the Bergamo marbles of Italy—the thousand and one marbles of Sicily—and generally speaking, the marbles of Spain, of Portugal, Switzerland, Germany, Norway, Sweden and Russia are of this formation: as was the red marble of mount Sinai.

But we need not look abroad for primary marbles. We have a locality of it at Kingsbridge; where it is coarse grained, and contains mica.

At Singsing is a much better and finer variety, and one that deserves to be employed more extensively.

The Schuylkill marble is extensively and deservedly used in the arts—

The Potomac breccia marble is susceptible of a high polish, and is employed extensively—the va-

riety of color, and shape of the imbedded minerals give it a beautiful appearance. The shafts of the columns in the hall of Representatives in the Capitol at Washington are of this breccia: they are nearly 21 feet from base to capitol, and 2 feet in diameter. A block of 70 feet long, with a base of 11 feet by 71 has been procured.

The quarries of New Milford, about 3 miles from New Haven, afford fine and beautiful marble—similar to the verde antique.

The Swanton marble (Vermont) is a superb and excellent variety, and will eventually be much used.

The Smithfield marble of R. Island is valuable.

The marble quarries of Massachusetts are the most valuable in this country.

The West Stockbridge marble is much used—and produces to the owners about $30,000 annually. In Lanesborough about $10,000 worth is yearly sold. The marbles of Berkshire sell for about $40,000—and those of Sheffield for $8,000 yearly.

Primary limestone is found in strata, of all forms and magnitudes—also in nodules or large irregular masses, in gneiss, and in veins, when it is crystalized. In the Pyrennees, it is considered by Charpentier as an independent formation. In South

America it is found, coarse grained and white, similar to the finest Carrara, which Humboldt for a long time thought an independent formation. In the Pyrennees and in the Alps it is common, but in America, beds of it, subordinate to rocks of granite-gneiss, are more rare.

In Scotland it occurs in granite; when it is associated with mica slate or gneiss, the mica enters into its composition and gives it a laminar structure. The beds usually follow the direction of the accompanying rocks.

The following minerals, with others, are found in limestone:

Serpentine,	Stilbite,	Actinolite,
Steatite,	Olivin,	Asbestos,
Garnet,	Idocrase,	Mica,
Emerald,	Tabular Spar,	Talc,
Beryl,	Tremolite,	Chlorite.
Spinelle,	Sablite,	Quartz,
Titanite,	Augite,	Brown Spar.
Sphene.	Hornblende,	Pyrites.

QUARTZ ROCK has been established as holding a place among the primary rocks. Dr. Macculloch, Humboldt, and Von Buch first gave us correct ideas of it.

It is generally white, with a smooth, brilliant surface, or is tinged with reddish, yellowish, or dark purple tints.

Its aspect is usually granular—the size of the grain varying: rarely is compact or crystalline. In its purest state it has different aspects: thus, in some cases, it has a granular, crystali ed appearance: in others, the texture is a mixture of the mechanical and chemical: and again, it is purely mechanical. The cavities may contain regular crystals.

When much blended with felspar, it takes the reddish tint of that mineral, and the texture becomes changed, so as to exhibit a mere agglutination of grains of different sizes, and in different proportions. It has a foliated disposition, and the laminæ are easily separated into very thin plates.

This rock is sometimes found to contain mica, particularly when resting on mica slate, and is split into laminæ of such thicknes, as to allow of its being used for architectural purposes.

A simple quartz rock 1800 feet thick exists at an elevation of 1600 feet above the sea in South America.

Like the primary rocks, with which it is in connection, it is stratified; the distinctions of beds being as decidedly marked in some cases as in sandstones. The dimensions vary from an inch to many yards; and having natural joints, they break into rhomboidal or prismatic fragments.

It has no certain position, being occasionally found alternating with all the primary strata.—When alternating with gneiss the limits are scarcely discernable, as the felspar becomes gradually more abundant, and the other components less.

When alternating with mica slate, its beds are very thin, and the mica insinuates itself into the mass—thus producing a very gradual change, so as to render doubtful the line of demarcation. This is not always the case, for when they alternate in large beds, the outlines are much more decided.

Quartz rock alternates with argillite also, in laminæ of various dimensions; generally on a small scale. In some cases, they almost insensibly glide into each other; in others their separation is very distinct. It alternates also with greywack schist; and sometimes, says Dr. Macculloch, with primary sandstone, which it strongly resembles, but always on a larger scale.

M. Von Buch remarks that in Scandinavia the primitive clay slate is sometimes represented by quartz rock, thus making them geognostic equivalents.

In South America, the quartz rock has been examined by that indefatigable observer, Humboldt. He found this formation containing alternating beds. 1—auriferous quartz. 2—chlorite

slate. 3—auriferous quartz and tourmaline. 4—auriferous quartz and specular iron; and some of these beds are 1000 feet thick. It is to the destruction of these beds that some suppose we are origionally indebted for platina, gold and diamonds, and also for the topaz and euclase of Brazil.

Some English geologists have denied the right of quartz rock to a separate place; and chiefly because there is so small a quantity of it in Europe: But in America it decidedly takes rank—a locality of it is seen running from Canada, through Vermont, Massachusetts and part of New-York, an extent of more than 300 miles.

At Brighton, near Boston, it occurs of various colours.

It contains few imbedded minerals: garnet, hornblende, titanite and oxydulous iron occasionally occur.

Chlorite Schist has only lately been deemed of such importance as to be called a rock.

It is of a greenish color, passing into grey, and into the pale grey of the micaceous schist. The greenish specimens have the most lustre.

It does not form very extensive tracts of country, but is sufficiently well marked in its charac-

acters to induce the best geologists of the present day to assign it a distinct name.

It is so nearly allied to micaceous schist, with which it is intimately associated, that some geologists have doubted the propriety of a separation. It alternates also with gneiss, and by insensible degrees enters into that rock. With mica schist, argillite, gneiss and primary limestone it forms a very interesting geological series in Scotland.

When the beds are thick, it is strongly assimilated to mica schist, is flexed and is imperfectly divisible. It is more generally the case that the strata are thin, when it is more easily split into laminæ, but is seldom applicable to economical purposes.

In texture, it partakes of the characters of the rocks with which happens to be most intimately united at the locality—as micaceous schist, gneiss, argillaceous schist. It never contains fragments of other rocks.

The essential constituents are quartz and foliated chlorite, which is to be distinguished from scaly chlorite. The green tint of the former is the most convenient character by which to distinguish it from mica, and from micaceous schist.

Other minerals occasionally enter into its composition, as felspar, hornblende, mica, actynolite and compact felspar.

The imbedded minerals are usually crystallized chlorite, quartz, oxydulous iron, tourmaline, brown spar and pyrites.

East of Troy chlorite schist occurs in strata between two and three miles wide, and sometimes rising into hills 200 or 300 feet high.

On the Milford Hills, in Connecticut, it is found in strata between primary limestone and hornblende; and at West Haven, it forms extensive strata, passing perhaps into argillite.

Talcose Schist is another rock that has only been lately spoken of separately in geology and it is to the observation of Macculloch that this, as well as the last rock, owes its elevation.

It is similar to the preceding rock, being composed of talc, or talc and quartz, with an occasional, though rare, intermixture. Its colors are white, lead grey and dark obscure green. The peculiarities of talc sufficiently distinguish it from other rocks.

It is not common, nor abundant—but alternates very distinctly, as a rock, with other primary strata. The constituents of chlorite or micaceous

schist give those rocks a very different character from the present.

The strata are usually thin; and it might have been retained as a simple mineral did it not occasionally show itself in large masses.

Associated with hornblende schist, it often forms thin beds in a series of gneiss. It is often formed by an imperceptible passage from micaceous schist: sometimes too from chlorite schist; and occasionally from argillaceous schist. In all these cases, the two first particularly, it is associated with minerals having an affinity to talc, as steatite and asbestos. It is also associated with serpentine.—It presents no structure particularly to be noticed: it is sometimes minutely undulated, but not flexed like micaceous schist.

It contains the following minerals.

Asbestos,	Diallage,	Chromate of iron,
Actynolite	Automalite,	Pyrites.
Cyanite.	Staurotide,	

Perhaps the regular strata of talc, described by Professor Hall, as occurring in Windham, Vermont, is Talcose Schist.

HORNBLENDE Rocks have given rise to much discussion in Geology, and are variously viewed by different Geologists.

Brochant arranges under this head greenstone, greenstone porphyry, and verd antique.

Bakewell considers Trap as a generic term, embracing greenstone, basalt, amygdaloid and whinstone.

Eaton includes primitive trap. sienite, greenstone porphyry and green porphyry under the Hornblende Rocks.

Macculloch, under Hornblende Schist, speaks of hornblende rock, primitive greenstone, and greenstone slate.

When hornblende becomes slaty in its structure, it is usually termed *Hornblende Slate.*

When intermixed with felspar, it is then *Greenstone.* The proportions of the two ingredients are different; but the hornblende usually predominates and gives the greenish tinge. If this variety become slaty it is called *Greenstone Slate.*

Hornblende rocks are not always composed of but two constituent parts: sometimes admitting into the compound quartz, mica, talc, lime and iron, which latter decomposes by the action of air, and disintegrates the mass. Epidote is occasionally present in these rocks, which are then susceptible of a fine polish. When the felspar is in crystals it is called porphyrytic greenstone; and this variety, when very dark and fine, was called by the an-

cients *Black Porphyry*. The green porphyry of the ancients is very compact, and embraces crystals of felspar. It is often colored by epidote.—This is found near Boston.

Greenstone beds are occasionally very large, forming mountains,usually conical, with mural precipices. It is not confined to the primary class.

In this country it is common. It forms the summits of all mountains between the primary range and the Hudson. The Palisades are of this rock; as is Mount Holyoke, in Massachusetts, where the columns are from 60 to 100 feet long, articulated like basalt. In Maine, on the Kennebec, it also occurs.

Dr. Macculloch terms them all Hornblende Schist, on the supposition, that the other rocks, usually called hornblende, are but subordinate parts of the great beds, having the schistose structure—and that the structure varies from massive to schistose in the same bed. Humboldt thinks the independence of greenstone slate doubtful.

Hornblende Schist rarely forms extensive tracts, without alternating with other primary strata.

Its most intimate association is with gneiss, in moderate and thin strata, so as almost to form a subordinate bed, but in other cases to equal it in quantity and importance. It follows the flexures

of gneiss and is penetrated by the same veins of granite—passing however into gneiss by the acquisition of quartz, and alternations of hornblende. In the same way it also alternates with, and insensibly runs into micaceous schist; in which it is usually accompanied by chlorite schist, presenting sometimes a prismatic structure. It is not often associated with argillaceous schist, but is occasionally, when it also passes gradually into that rock. It passes into Actynolite schist, which is erected into a separate rock.

It often presents minute undulations, like micaeous and chlorite schists, besides following the large flexures of the laminar varieties.

The texture varies according to the component parts—but the granular, crystalline, and laminar are the most common: in the latter case being fissile; in the former, massive—(being the hornblende rock of many.)

It has not been found to contain fragments of other rocks, and its texture may be set down as truly crystalline or chemical.

Its components are felspar and hornblende, often the latter alone: thus differing from micaceous and chlorite schists, which always contain two minerals, one of them essentially quartz. Mica

and Chlorite only are very rarely contained in such quantities as to alter the genuine rock.

The color is black or a green so dark as not to be distinguished from it. The colour of the felspar produces varieties of shade, as it approximates white, green, or red.

Pyrites and garnet are the only minerals found in this rock—the latter sometimes very abundant.

It is used for building stone, and in the preparation of water proof mortar.

Actinolite Schist is mentioned by Macculloch as a distinct rock; thus following, as he remarks, the ideas of Saussure, who asserts that it occurs in gneiss, under a distinct character.—It is distinct from chlorite schist. In all its associations it is similar to hornblende schist, with the exception of a more intimate connection with chlorite schist. It differs from hornblende schist in composition, only by the substitution of actynolite for hornblende. It is to be remarked, that while actynolite continues to be considered as a distinct species from hornblende, so long must the two rocks be separated.

At Brunswick, Maine, it forms a stratified rock of considerable extent, associated with granular quartz.

Porphyry has been placed among the primary rocks, though Humboldt doubts its existence as such, unless in subordinate beds—in the same way that gneiss and mica slate of the high Alps, become granular, and, from the insulation of felspar crystals, assume a porphyritic aspect. He considers porphyries as more closely connected with coal-sand-stone.

Porphyry has a compact base, containing crystals distinctly visible, chiefly of felspar or quartz, the base forming the specific term, as compact felspar, or clay stone, pitch stone, or clink stone. Its color is reddish, brown, purplish, or green. Its general appearance is not unlike granite.

Felspar porphyry is found near Boston, and equals in beauty the antique varieties. The base is compact felspar, and has been mistaken for jasper.—It is occasionally slightly granular, or a little foliated. The fracture is usually conchoidal, somewhat splintery or uneven. It gives fire with steel. When the crystals of felspar decompose, small cavities are produced: even the base is liable to decomposition, but is protected from the action of air and moisture by being polished. It is often susceptible of the finest polish, and has been much employed in the arts. It is very du-

rable, and was highly prized for architectural purposes by the ancients. The extreme hardness alone of porphyry and granite has caused their neglect. It should not form an objection. Independent nations who build not in fear of revolutions should have durable materials.

Some of the most beautiful ornaments of Rome are of this substance; the urn of Constanza and the urnof St. Helena are each formed from a large block of porphyry: and the great tazza, or saucer shaped reservoir in the rotunda of the Museo Pio Clementino is one immense piece of porphyry. Pliny says that the sculptors began to use porphyry under Claudius. The room in which the princes of the Greek empire were born was encrusted with it: and these princes were called Porphyrogeneti. The name of this stone was taken from the ancient purple dye made of the Tyrian shell fish called porphyrios, whence it is supposed that the ancient dye was of this dull red colour.

There is a small grained greenish porphyry, more highly prized than the red variety.

Sienite is another, and the last of these rocks. By the substitution of one ingredient for another, granite is so insensibly converted into sienite, that

at first sight it does not strike us. This is effected by the existence of hornblende in the granite, which becoming more abundant, at last supplies the place of quartz, and forms a compound of which hornblende and felspar are the two constant and essential constituents:* but in which mica and epidote may occasionally blend. Felspar is usually the most abundant, and occasionally the hornblende is in very small quantities. The necessary presence of hornblende as an ingredient, distinguishes this rock from granite in which hornblende is imbedded.

It derives its name from Siena in Upper Egypt, where it abounds, and whence it was brought in great quantities for employment in architecture and sculpture, by the Greeks and Romans.

Its structure is granular and sometimes slaty.

The color varies with the predominating constituent; the hornblende often gives it a greenish tinge, as does epidote: the felspar is mostly reddish, or whitish. When there are large crystals of felspar contained in a fine grained sienite, the mass is termed Sienitic Porphyry. It will have been observed, that sienite and greenstone are both composed of felspar and hornblende. They are in fact the same rock varied by a transition so gentle as to be imperceptible: thus, granite

changes into sienite, which runs into greenstone: but that section of the chain in which hornblende predominates is greenstone, and where felspar is the most abundant, it is sienite.

This rock is occasionally associated with all the primary rocks, resting on granite, gneiss, and argillite—and alternating with all the lesser members of this family.

It is not an abundant rock.

It is plentiful on the west shore of Lake Champlain.

In many places in Massachusetts it is so abundant as to be quarried. The Stone Chapple in Boston, the State Prison at Charlestown, and the prison at Lechmere Point are of this stone.

The two celebrated lions at the steps ascending the Roman Capitol are of sienite; as is also the famous Collosal Egyptian Head in the British museum.

Humboldt doubts if it ever occurs as a primary rock, except as a subordinate bed, or as an independent primary formation. Such he thinks are some sienites resting on gneiss, and partly covered by primitive mica slate. He mentions the Sienite of Paramo, placed on granite and covered by slate.

These are the substances usually treated of in Geology, under the head of Primary Rocks: to them Humboldt has added "EUPHOTIDE," a variety of serpentine rock; or a mixture of diallage and lamellar felspar. It is the Gabbro of de Buch. It seems to be most intimately connected with mica slate and hornblende schist.

All these rocks are not necessarily present in every primary country: i. e. they do not universally hold the same position, since part of them may be absent. Indeed we have been taught during the last twenty years, as M. Humboldt says, that we are not to expect precisely the same relative position in the constituents of the great formations. The great laws, however, regulating the succession of rocks, in the structure of the globe, are in all countries the same; and striking analogies in the position, composition, and included organic remains of contemporary beds exist universally: and viewing formations in a general way we are almost taught to believe their universal identity. But identity of formations is not to be looked for, any more than the constant operation of the same law in mechanics. Like causes produce like effects—but obstacles may present occasionally to interrupt them—thus occasionally one rock may represent another: in which case there is not

an identity in all formations, but parallel formations, or geognostic equivalents. Nor in comparing widely distant countries, are we to look in one country for an equivalent for every rock in the other, as one formation may represent many others. Thus the beds of clay below the chalk, in France, may be easily separated from oolitic limestone*; but in our hemisphere, South of the Equator, they have marl for geognostic equivalents to represent them. And these beds, by the way, may in the same manner, represent the chalk in the United States.

The striking similarity of structure in different countries has been examined and acknowledged by the best geologists: thus the position and succession of formations has long been a subject of study to Humboldt; (whom I liberally resort to) and in South America he soon recognised the conformity of superposition in the two continents, and found them fully develloped in the formations exhibited from the 21° N. Lat. to the 12° S. Lat.—where he says the types were rather enlarged than altered. From the Canary Islands to within the polar circle (as far as the 71° N. Lat.) we have undoubted testimony of the uniformity of position, and of the analogous features that characterise formations in the most distant regions.

The associations of rocks, upon comparing immense fields of observation, we may say, are nearly as constant as their composition. The compounds are made up of the same simple minerals, and in turn compose mountain masses, in which the same rocks are found in a similar position.

This uniformity of position is observed usually in rocks of all formations—but more particularly in the larger, or older, as in the Primary and Secondary: it does not follow that it is found in independent formations. These independent formations are so called from the fact, that they rather escape the law of uniformity of position, being placed indiscriminately on granite, micaceous schist, and secondary limestone. The position of independent formations however does not necessarily exclude uniformity of position.

It has been doubted by some whether the same rock was deposited at the same time in different parts of the globe.—Most Geologists assign the same date to a deposit wherever it may be found: this is expressed by the term *Isochronism* of formations. Formations of analogous composition are allowed to have been produced at different and distant periods—these however are formations not included in this general law—as Primary and Se-

condary Limestone. Organic remains go far to prove this Isochronism, and the existence of the same fossils in similar though distant beds affords strong proofs.

"It has more than once been desired that we could find a supplement to our short annals in the monuments of nature. The historical ages might, however, have sufficed to teach us, that the succession of moral and physical events is not regulated by the uniform process of time, and cannot, in consequence, furnish its measure. We see, in looking back, a succession of creations and distinctions, by the various arrangements of beds that form the crust of our globe. They give us an idea of several distinct epochas: but these epochas, so fertile in events, may have been very short, compared to the number and importance of the results. Between the creations and destructions on the contrary, we see nothing, whatever might be the immensity of the intervals; there every thing is lost in the mist of indeterminable antiquity, the degrees of which cannot be appreciated, because the successsion of phenomena has no scale that can be referred to the division of time." (Mem. de l'Institute, 1815.)

I have mentioned that several of the rocks we have described, *alternate* with others, with which they are associated. When the same rocks are placed several times alternately upon each other, they are said to alternate, and it is often by this interchange of places, that they insensibly become blended and run into each other. Thus when two formations succeed each other immediately, it generally happens that beds of the one begin at first to alternate with beds of the other, until a new formation succeeds without any subordinate beds.

In primary rocks the three most ancient are said to be either insulated, or alternating two and two, or all three alternating together. Granite and gneiss in some cases are constantly associated, in others gneiss and mica slate. In all cases there are certain laws ;—granite, gneiss and mica slate are found in a triple association ; but granite alternating with mica slate only, or gneiss and mica slate alternating with argillite only, are said not to occur. Those rocks passing insensibly into others with which they are in contact must not be confounded in this way—as micaceous schists that *oscillate* between gneiss and argillite, are not to be confounded with such rocks as alternate, and preserve distinct all their characters.

In treating of mountains, I have mentioned their usual direction as being frequently the same.

The parallelism of beds, called also *Loxodromism*, is very surprising. The primary beds on the coast of Genoa, the plains of Lombardy—the Alps of St. Gothard—Swabia and the north of Germany, were first noticed by Humboldt to run almost constantly from south west to north east—and this was one of the reasons that led him to South America, where he noticed the same in the chain of mountains running from the lower Oronoko to the basin of the Rio Nigro, and the Amazon. This Loxodromism has already been mentioned in speaking of the uniform direction of mountains from north east to south west.

This is the direction of our Allegany Mountains, one of our most interesting geological features. From the sources of the St. John River, New Brunswick, it runs south west to the junction of the Alabama and Tombigbee Rivers. At the distance of from 40 to 80 miles it follows and skirts the Atlantic, forming a mighty barrier to a mighty ocean.

Granite, gneiss, and micaceous schist, each form a considerable part of this immense ridge. Granite is found on the tops of mountains and on

plains, and is frequently so decomposed as to have lost adhesion for 50 or 100 feet below the surface, exhibiting only sand and gravel.

Gneiss is more widely distributed—and covers nearly half of the primary ridge, including immense beds of granite, some of them 300 feet thick; in which beds are found the Emerald, Tourmaline, Garnet, &c.

Micaceous Schist and Argillite are also widely distributed.

Primary Mountains may be said generally to be unfavorable to vegitation: their extreme hardness, their precipices, and unfriendly soil, doom them to barrenness. Lichens and mosses attached to their sides decay, and furnish soil for larger plants—Water penetrates and breaks off masses—the influence of air, water, heat and light assist in the progress of disintegration—and insensibly, but uniformly and constantly, aid in converting stones into bread—or, in other words, in preparing soil from the most sterile rocks for the support of animal and vegitable life.

The decomposition of granite is slow, and when decomposed the unfriendly siliceous grains are easily washed away. There is neither vegitable nor animal matter in the compound; it does not absorb

moisture, letting the water percolate ;—nor does it retain heat.

The soil made from gneiss is not washed away quite so easily—and the mica yields it more argillaceous earth—but it is seldom deep (from 20 to 100 feet.)

Micaceous Schist and Argillite decompose more rapidly, and form a better though not a good soil.

The rivers of primary districts have rocky beds and precipitous banks.

Upon the whole, Primary Mountains are covered with a soil less productive than the other classes of rocks—and form the barren regions of the Arctic, and the sterile plains of the Torrid.

To compensate, in some degree, their water is more pure and clear, and the inhabitants more healthy.

LECTURE VI.

Transition Rocks—-Argillite—Greywacke—Limestone—-Gypsum—-Porphyry—Sienite—Greenstone.—Secondary Rocks—Observations on their Formation—Old Red Sandstone—Coal—Indications of it, &c.—Shale—Limestone—Rock Salt—Variegated Sandstone—Shell Limestone—Lias—Oolites—Iron Sand--Green Sand—-Chalk. Tertiary Formations—-of France, England, and the United States. Alluvia—Diluvia—Overlying Rocks—Conclusion

Resting on the Primary Rocks already described, we find others, that have been denominated by Werner, Transition, by others, the Intermediate, the Medial, the Sub Medial, and by Hutton, the Stratified. They never attain the elevation of the preceding rocks, and are more liable to decomposition. They are considered as not crystalline. They are the oldest or lowest rocks in which we find any record of vegitable or animal existence, and may be regarded as ancient re-

cords, imprinted with the natural history of the inhabitants of the globe.

They repose on the primary class, and form a contrast to their bold precipices and rugged peaks, by their less pointed, and more beautiful outline.

In retaining the term Transition, I do violence to my own opinions. The division of rocks in which that term is adopted is unnecessary and perplexing. I have elsewhere given reasons for not employing it—the following may be mentioned.

The Rocks called Transition, are often as purely chemical in composition as any other rock.

Many of them contain no organic remains.

There is no definite boundary between them as a class and the primary. And lastly it is a division of no practical importance ; and one that is very perplexing to the student.

In America, they have no line of demarcation, and are often absent altogether.

If we place these rocks among the primary, as some Geologists do, we shall then have natural limits to every class—the red sandstone being placed between the primary and secondary—and the chalk between the secondary and tertiary.

I shall however retain this name, as I do not consider my own authority sufficient to banish it,

although in so doing, I should but follow the most natural division, and be upheld by some of the best geological enquirers.

The rocks usually described as transition are but varieties of those we have already mentioned—viz.

Argillite,	Porphyry,
Greywacke,	Sienite,
Limestone, (metalliferous)	Greenstone.
Gypsum,	

Argillite.—It is but a few years since this rock has been assigned to different formations; having until lately been termed Transition. But when enquirers into nature began to examine for themselves and were no longer led by the great masters of the opposite schools, the structure of the Earth was more thoroughly examined, and new facts discovered, which tended to clear up many of the supposed inconsistencies in geological speculations: thus the oscillations and alternations of beds and strata cleared up the supposed irreconcileable positions in which masses were occasionally found, and which no theory accounted for.

The composition of transition Argillite is the same as that of the primary, viz. Siliceous and

Argillaceous Earths, Magnesia, Lime, and Oxide of Iron.

It has various shades of grey, varying to purple, red and green.

It is soft and easily decomposed; and is fusible. It rests upon gneiss or mica slate. It contains beds of limestone, and alternates with the rocks in its vicinity, frequently having greywacke interposed.

It splits into laminæ, and is then useful for various purposes: that which is easily divisible into thin plates, and is compact and sonorous, is termed roof slate.

Some varieties of it are used for writing slates. It frequently abounds in iron pyrites, which renders it unfit for use. It also contains alum slate, and flinty slate.

It is an abundant rock. That termed transition is more plentiful than that before noticed. The elevations composed of it are usually tabular and flat.

I have already mentioned that Argillite is quarried in Rensselaer County.

In the vicinity of Hudson, it is seen forming the banks of the river, and is found on and near the banks of the Hudson as far north as Fort Miller.

It frequently contains metallic treasures. In Guanaxuato, in New Spain, this rock is traversed by a vein that for 17 years produced annually 556,000 marks of silver. A mine in this rock in Valencia yielded 360,000 marks of silver annually for 40 years.

Argillite sometimes contains porphyry and sienite. In the North of Europe the three alternate.

When Argillite contains imbedded grains and masses of indurated clay, quartz and flinty slate, it then forms what is termed

TRANSITION GREYWACKE, denominated fine or coarse according to the size of the grains: when the former variety is slaty, it is then called *Greywacke Slate*, which is in fact coarse argillite, and by a combination with mica, passes into mica slate. It alternates with flinty slate and limestone. In England two formations of Greywacke alternate with two formations of limestone.

It is closely allied to the preceding rock, argillite passing into greywacke slate, which has a homogeneous appearance and a slaty structure.—It is distinguished from it only by its grey color, and by the glimmering of the mica it contains.

In a general sense, Greywacke means, according to Humboldt, every conglomerate, sandstone, or puddingstone, fragmentary or arenaceous rock

of transition formation, that is anterior to the red sand stone of the coal formation, (old red sand-stone.) In a more limited sense, it is confined to the arenacious transition rocks, which contain only small fragments of simple substances, more or less rounded; for instance, of quartz, of lydian stone, of felspar, and of clay slate, but not fragments of compound rocks. In the latter case, the term greywacke is inadmissable, and the name of *breccias* or *conglomerates, with large primitive fragments*, is given to various agglutinations of pieces of granite, gneiss, and sienite.

Calcareous puddingstones are those in which rounded fragments of carbonate of lime are cemented by a base of the same.

Coarse greywacke passes easily into conglomerates with large fragments, and alternates with those of fine grain and homogenious aspect. The puddingstones and breccias with large fragments of primitive and compound rocks are true greywackes.

Greywacke is metalliferous. It is often traversed by quartz. The novaculite, or hone slate, belongs to it, as does the rubblestone or rubblewacke which is connected with the Catskill Mountains.

Redwacke is seen in a layer between the village of Catskill and the mountain, which has now become so fashionable a resort.

Mr. Eaton says that this rock underlays all the western part of our state. In Rensselaer, Washington, and Columbia Counties, it is often met with covering extensive tracts.

Alternating with these two last mentioned rocks occurs a Limestone, called TRANSITION LIMESTONE, *Metalliferous Limestone, and Carboniferous Limestone.* Part of this formation is the *Mountain Limestone* of some Geologists, who treat it separately. It is compact and has not the crystalline structure of the limestone formerly spoken of. Werner called the lower beds of this rock transition limestone, and the upper he termed flœtz—but this distinction is justly abolished; and the two are properly spoken of together. Humboldt has divided it into granular talcose limestone, and black limestone, but places both under the same head. Their characters coincide—and it is only their relative position that induced Humboldt to give them these names in his excellent work on the superposition of rocks. They are both metalliferous, and contain traps and amygdaloids. They occur in vast masses, and form mountains with perpendicular cliffs and steep ravines.

The lowest beds usually rest on argillite, with which they alternate. They contain some carbon, (about 0.75 or ¾ pr. ct.) whence they derive their colors, which vary, usually having a greyish hue, and always darker than the primary. The strata are not well marked, and are of great thickness. Organic remains are rare in this rock—the catalogue is, however, very curious and instructive.—The black limestone contains orthoceratites several feet long—entrochites, madrepores, pectinites and ammonites. It is extremely difficult to draw the line of boundary between the upper and lower beds.

Some of the celebrated marbles of antiquity belong to this deposit—as the marmor luculleum—the nero antico—the African flowered marble—the pavonizzo, and, according to Humboldt—the gilded breccia.

I have already mentioned that a difference of opinion exists in regard to the manner in which we find the series of these rocks contorted. It is from the limestone series that many of the arguments are drawn.

The strata of limestone countries present many interesting phenomena—and which, if we allow the action of either of the discordant agents, is easily accounted for. The arguments of Hutton.

Playfair and Hall are specious, and to him who hears only the arguments of one school, carry conviction. That the undulations of strata have received their several characters in a horizontal position, can readily be imagined and easily acquiesced in. But not so with the irregularities, contortions and disruptions. Here the other school interposes, and is strongly aided by arguments drawn from nature. It must be admitted, that when Hutton allowed a certain agency to water, and a certain power to the action of subterranean heat, he combined the good of both theories, and appears above the rank of a *mere theorist.*

The upper portions of this deposit contain peculiar fossils—many of which appertain to species now extinct.

It is a singlar circumstance that a part of our globe should be covered by animal secretion, yet such is the fact, as was shown when speaking of coral reefs.

In this and the succeeding rocks, organic remains, or petrifactions. become so frequent, as by many to be supposed characteristic of the different beds in which they are found—Of the accuracy of these remains as a geological standard, I have spoken elsewhere; but I cannot omit here to

mention the sentiments of Humboldt, who, in treating of these rocks, observes, "Although we are yet far from being able to complete the history of many intermediate and secondary formations by an enumeration of the fossils found in them, we shall indicate some that characterise this group—(in which he includes transition argillite, with greywacke, greenstone, black limestone, sienite and porphyry.)

In argillite and greywacke, monocotytedon plants, perhaps anterior to the most ancient animals, entrochites, coralites, ammonites, hysteriolites, orthoceratites, pectinites, trilobites, in which no traces of eyes are discernable ; ogygies of Brongniart, in which the eyes are indicated only by two tuberosities on the scutum—(found in our country)—calymene of Tristan, and calymene macrophtalme of Brongniart.

In the most ancient beds of the limestone, entrochites, madrepores, belemnites, sometimes insulated ammonites, orthoceratites, asaphus buchii, asaphus hausmanii, and a very few bivalve shells. In the newer beds of limestone, calymene blumenbachii, (found on the Miami) asaphus caudatus of Brongniart, ammonites, terebratulites, orthoceratites, some gryphites, and encrinites."

This formation is to be studied in many places in the western part of our state. At Trenton Falls on West Canada Creek, a place now often visited, it contains many of the beautiful fossils peculiar to it. Orthoceratites, nautilites, terebratulæ, productæ, encrinites, and trilobites—among which is the beautiful new genus of Isotelus, lately instituted by Dr. Dekay.*

Gypsum, porphyry, sienite and greenstone are found among these rocks : Gypsum, however, does not occur in sufficient quantity to be noticed. Indeed it is doubted if in a geological system, it should be mentioned at all, except as an occasional rock, as other than secondary, it is so seldom found in this place. According to Brochant it is found in connection with transition limestone.

Porphyry, sienite, greenstone and amygdaloid have already been noticed : they occur here in small quantities as occasional rocks, or rather as alternating with others, and have some characters distinct from their earlier beds—being less crystalline and more compact.

Porphyry, having a base of indurated clay, is usually mentioned as transition porphyry. Its fracture is dull and earthy. It is moderately hard

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*See Annals of Lyceum of Nat. Hist. of N. Y. vol. 1.

and adheres to the tongue. The colors are grey, greenish, brown, &c. with a tinge of red or yellow. It sometimes presents a columnar aspect. Occasionally it contains nodules with a centre of calcedony. It is liable to decomposition, and resembles volcanic products. When in the vicinity of coal, it contains vegitable remains.

Porphyry alternates mostly with argillite, sienite, greenstone and black limestone.

In South America all the porphyry is found in the most western and elevated part of the continent, none being found east of the Andes, throughout the whole eastern part of South America.

The Cordilleras contain perhaps the greatest mass of porphyry: it is particularly rich in gold and silver; and associated intimately with rocks produced or changed by fire. The limits between the transition porphyry and volcanic rocks of South America are not easily traced.

The porphyry of Mexico is rich in silver and gold. The pit of del Encino furnished 50,000 marks of silver annually for a long time. In 1726-7, two workings in South America yielded 542,000 marks, almost twice as much as all Europe and Asiatic Russia in the same time.

Most of the porphyries of South America exhibit a tendency to a regular stratafication, which is seldom observed in Europe.

SIENITE and GREENSTONE have already been mentioned, as transition rocks; they occur in intimate association with each other, with porphyry and with amygdaloid; the hornblende of porphyry often becoming more distinct in the sienite, and finally abounding in the compact and sonorous greenstone. When the crystals imbedded in porphyry are exchanged for oval or diamond shaped substances, the mass is called AMYGDALOID. Indurated clay, greenstone, or wacke, may constitute the bed, and the almond shaped nodules may be calcareous spar, quartz, zeolite, hornblende, calcedony, agate, epidote, felspar, &c. &c. One mineral only is usually found in a cell; but occasionally there are two or three surrounding a nucleus.

At Mount Holyoke, in Massachusetts, it occurs precisely similar to some European localities. It is found near Boston, and frequently in Maryland.

In the synopsis at the end of this work, these substances will be found mentioned.

These are the unimportant varieties of the preceding rocks usually classed as Transition, but which in fact should be considered as primary, where Lehman placed them, and whence they should never have been removed.

We often find that novelties in Science are reprehensible. Few are capable of understanding and appreciating the many and often distant bearings that one point has upon many others, and of discriminating between the relations they bear each other. A fancied difference does not always constitute a true distinction. It is this accuracy of discrimination which placed some of the oldest naturalists so far above many of our own day; and assigns to Linnæus a place, to which all the research and philosophy of a more enlightened period can elevate very few of the living naturalists.

In accounting for rocks other than the primary, the theories of Geologists coincide, as both Werner and Hutton considered them as original depositions from aqueous solution—But the situation of the strata as we now find them, has caused much discussion. That they were originally horizontal is granted: the question is, how were they placed in the inclined or vertical position? The disciples of Werner, or the Neptunian school, suppose that in the original formation of these rocks, there existed immense caverns, such as we often see at the present day, and that these have fallen in, and thus caused the inclination of beds, &c.; a

supposition rendered in some measure probable by the immense extent of many existing caves—by the quantity of water now running through them—and by the great power which it is known to exert. In all Limestone countries they exist even now—and rain and moisture oozing through crevices may have filled many, more or less, the softer parts of the wall may have been dissolved or worn away—and the roof and super-imposed strata have fallen in.

It is urged against this theory, that instead of the strata having fallen in, the primary rocks have been forced up into the superincumbent mass.

The disciples of Hutton, or the volcanic school, conjecture that after these strata were hardened, they were elevated with the primary rocks, then in a state of igneous fusion, by some force below. The recent discoveries of Sir Humphry Davy have been supposed to throw light on the expansive power of heat, and to furnish strong evidence in favor of this theory, which is said thus to stand the test of experiment, and to be more clearly explained by the progress of knowledge. On the other hand, it is asked what is that influence exerted by Alpine chains on beds at the distance of of 400 miles? Is it a fact that there existed at the same great depth a force which heaved up mountains

and bent the strata of the plains, so that the bent edge of those strata, formerly horizontal, are now all inclined at nearly the same angle? Were the Alpine chains heaved up? If so, it is singular that they issued from fissures all parallel to the direction of the pre-existing inclined beds.

The secondary rocks repose universally on those we have already described. They are less elevated, and their angles with the horizon less than the preceding. They have an unconformable position to the primary, usually, though not necessarily. It may, however, be laid down as a rule, that all rocks succeeding to any one rock that is unconformable in position to the primary, belong to the secondary. Red sandstone is the lowest that has universally this position, and may therefore be justly mentioned as the oldest secondary rock, and all above it belong to the same class. They rest on the sides of primary ridges or at their feet, and compose the intervening vallies. Their texture is more or less earthy, very rarely crystalline. They are often mechanical mixtures composed of parts of the primary rocks, united by cement. Their horizontal position and the presence of large numbers of animal and vegitable remains are also characteristics. They are

usually unstratafied. None of these characters are so invariably marked as the geological position;—the associations of a rock being among its most valuable and steady characters.

The number of secondary rocks is much more limited than the primary, being confined mostly to sandstone, limestone and shale—but present a great variety in detail, even independent of their organic contents.

The extent and depth of secondary rocks are also more limited than the primary. If they were not often absent, the primary would never be seen on the surface. The primary, in fact, constitute the great mass of the globe—while the secondary are partial, as a covering to them. The primary may be considered universal, since they bear the same characters in every part of the world; and could we have access to them, they would most probably be found in a similar and uniform position every where. The secondary can only be considered universal, inasmuch as similar rocks occur, as far as their chief characteristics are concerned, in every part of the globe. But they are not continuous, and therefore only partial—even perhaps partial in a more limited sense, as some varieties are peculiar to certain countries, and not found at all in others. Their laws are not so gen-

eral, operating only on a limited or local scale, while the laws of the primary seem to have extended over the whole globe.

The occasional absence of these secondary is owing to two causes. The action of the elements, which in the lapse of ages, must have destroyed them partially; and the original deposition seems to have been often local, and confined to concavities, technically termed basins.

The chief members of the Secondary Class may be reduced to four, viz.

1. Red Sandstone, or Great Coal Deposit.

2. Alpine Limestone—or Magnesian Limestone: with Rock Salt.

3. Arenacious and Calcareous Deposits; which embrace the variegated sandstone, or new red sandstone, gypsum and rock salt, shell limestone, sandstone, lias, marle, oolite, ferruginous sand and green sand.

4. Chalk.

Red Sandstone is one of the most important rocks of this class. It is also called old red sandstone to distinguish it from a newer variety called also red marle or variegated sandstone.

It is formed of the fragments of the preceding rocks or minerals—varying from coarse to fine, according to the size of the grains.

It rests always on the preceding rocks ; varying in appearance as it is more or less mixed with adventitious minerals. The simple minerals entering into its composition are quartz, felspar, clay, mica, and carbonate of lime. The rocks, which by their fragments, contribute to the formation of this one, are all of the primary class.

It contains few imbedded minerals, which remark is applicable to all the secondary rocks—Sulphat of strontian and calcareous spar are the most common.

It contains very few organic remains.

Its color is red as the name denotes—varying from a bright ochre to the darkest brown, or even blackish purple.

This rock is so immediately connected with coal, as to be treated of with it in all works on geology.

Where beds of old red sandstone are associated with calcareous beds, good soil is generally produced.

The summits of mountains composed of this rock are mostly covered with mosses.

Coal is so intimately associated with this rock, that I cannot persuade myself to pass it unnoticed. Indeed its value and importance to our city ranks it among the most useful of all formations, and one of the most interesting of all mineral strata. I may perhaps be allowed to dwell upon it, as it is a subject of primary interest to our City and State.

The oldest variety of coal that exists is the slight trace of carbon that we find occasionally in primary rocks; but never in sufficient quantity to work.

We are not to look for coal in any of the rocks that we described at our last lecture; nor in those that I have just mentioned It is never found in rocks older than the red sandstone, in connection with which it is most generally found, occasionally alternating with other rock or earthy strata. It forms one of the most important branches of geological science.

The lateral extent of coal deposits, often called coal fields, is sometimes very considerable.— In many places they occupy basin shaped cavities, having all the edges turned up, and perhaps cropping out: In other places they are inclined at such angles that their extent cannot be known, or conjectured. It is usual for more than one bed to be

found in a deposit; and sometimes ten or twenty are found. At Liege there are sixty beds alternating with sandstone, limestone, shale, clay and sand. The thickness of a bed varies from an inch to many feet or yards.—The strata are generally divided by natural joints, more or less perfect and extensive, by which they are formed into cuboidal or prismatic masses.—They are usually laminar.

The mineral composition of coal does not strictly come within my province, yet as it is not generally understood, it may be noticed in the briefest possible manner.

All the Bitumens from Naptha to Asphaltum, consist of compounds, apparently indefinite, of carbon and hydrogen principally: the small quantities of oxygen and azote which they contain, appearing to have little or no effect in modifying the mineral characters. In the most fluid, the hydrogen predominates, diminishing progressively according to the order of their relative tenacity or solidity. Where asphaltum ends this series, cannel coal, with some interruption in composition, and a considerable one in texture, commences that of coals. From this variety down to the most perfect anthracite, there is a similarly indefinite range of composition: the hydrogen generally diminishing as

the coal becomes less inflammable, as it is less capable of being separated into bitumen and charcoal by distillation, and as it yields a smaller comparative proportion of the former. Thus the composition of the bitumens illustrates that of the several varieties of coal. The most perfect anthracite appears to yield no bitumen, yet it contains hydrogen perhaps in every case; as that element is present even in common charcoal, which is itself a compound substance. Where anthracite passes to plumbago, which may in fact be considered as the true end of this series, the hydrogen seems to have disappeared; and if this substance be not mere carbon, as it probably is not, from the apparent combustion which it undergoes, on exposure to air, when its base has been extricated from iron under water, it undoubtedly approaches nearer to that element than any of the preceding substances.

We all know that there are several varieties of coal, and that it is of the utmost importance to us as housekeepers as well as proprietors of land to know their distinctive characters and names.

Anthracite, or native mineral carbon, or blind coal is the first we shall notice. It is not, strictly speaking, a coal, though combustible. Its color is black or brownish, but seldom the black of true

coal. It presents the most beautiful irised or tarnished colors. It is harder than common coal, but breaks easily. It soils the fingers—has an unctuous feel—and is somewhat slaty. It burns slowly, and with difficulty—yielding little or no flame, nor smoke, nor bituminous odour. After burning it leaves about 23 pr. ct. of grey ashes. It yields no bitumen, and the very feeble flame. which it occasionally exhibits, appears to arise from the hydrogen of the water it contains.

Anthracite, like the Diamond, appears to be essentially composed of pure carbon, but in a very different state of aggregation. That from Kilkenny yields 97 parts in 100 of carbon—that from Rhode Island 95.

When once ignited, Anthracite yields an intense and lasting heat—and much of the difficulty of kindling it may be avoided by the addition of a certain quantity of charcoal, and by the proper application of a strong current of air.

Being composed mostly of pure carbon, without any bitumen or sulphur, except occasionally from pyrites, it burns without caking, and is very useful on all occasions where strong and uniform heat is requisite. In all manufactories, and for the forge, it is inestimable.

In speaking of the primary rocks, in our last Lecture, I mentioned that they contain no coal; i. e. —we know of no coal mine in such rocks as granite, gneiss, &c.—But this Anthracite, which I have stated is not a true coal, is found in the primary rocks. And hence it is obvious that this combustible has not proceeded from the decomposition of vegetable substances, since it is generally acknowledged that the primary rocks were formed previous to the existence of vegetation.

We have abundance of this combustible in the United States.

Rhode Island coal is this very substance. It is there found near the surface covered by shale and sandstone. It contains 94 pr. ct. of pure carbon. In *Massachusetts* also it is found, and in some of our new states. In Arkansas it is of good quality and in abundance.

The most extensive locality, and of the greatest interest to our city, is in Pennsylvania, on the north east branch of the Susquehannah, and near the heads of the Laxawanna, Fishing, Muncey, Lehigh and Schuylkill rivers. It extends down the Susquehannah to within 10 miles of Sunbury, and down the Schuylkill to within 20 miles of Reading, and is lost under Peters' Mountain. From the north east branch of the Susquehannah, it ex-

tends about 30 miles east, but only 2 or 3 west.—At Wilkesbarre, it runs under the river. It appears also at the surface of the country in beds of from 20 to 30 feet thick. This extensive formation is worked at several places—and the Lehigh, the Schuylkill, the Wilkesbarre, and the Laxawanna (or Laxawaxen as it is called) are from different parts of the same bed, and derive their names from the places near to which it is worked. At Wilkesbarre, it is quarried at the surface by means of gunpowder and wedges.

The Lehigh coal, which is quarried a few miles from the river, has been deservedly brought into use—and is supposed to be worth double the value of Virginia coal.

The Schuylkill is in all essentials the same.

The Laxawanna is from the north east portion of the same bed—and has rather a larger proporportion of bitumen—so that it affords rather more flame, and cakes more than the others.

We will all have an opportunity soon of forming correct estimates of their comparative value.

Besides Anthracite, there is another mineral often spoken of as coal, which is in fact a different substance. I mean Lignite, of which there are everal species, all derived from wood that has

been buried below the surface, and decomposed. Jet, of which ornaments are made, is one species. The Bovey coal of England, is of this kind. It does not occur in such quantities as to be quarried for fuel.

At Cape Sable (Maryland) it occurs in beds of 5 or 12 feet thick. At Martha's Vineyard it occurs in small quantities.

True coal is always black, and shining, compact, and with an even fracture. It is too hard to be scratched by the finger nail.

True coal burns easily, with a whitish flame, yielding a black smoke, and a slight, *but not unpleasant* smell of bitumen. It never leaves less than 3 pr. ct. of residuum, sometimes much more.

It is essentially composed of charcoal and bitumen, in different proportions, the carbon chiefly predominating, and sometimes composing 3-4 of the whole.

It is easily distinguished from Anthracite, which burns with difficulty, does not give a white flame, nor the black smoke, nor the bituminous odor of coal.

The different coals pass into each other, but seldom or very rarely pass into anthracite.

The cannel, candle, or parrot coal, the slaty coal, the coarse coal, and the sooty coal are only varieties.

Coal is usually found in beds, at greater or less elevation. At New Castle, where there are 27 beds, it is upon a level with and below the sea.

At Whitehaven it is 400 yards below the surface, and the working extends 1700 yards beneath the sea.

In our country coal is found at no great elevation: but in South America, at the table land of Santa Fé de Bogota, it rises 1360 toises, or 13.500 feet above the level of the sea, and at Huanuco, it is 2300 toises above the sea, and near the limits of perpetual snow.

The *Origin* of coal is by most geologists attributed to the decomposition of vegetable matters in the interior of our earth. The remains of vegetables that accompany coal, and the carbon and hydrogen of its composition, render this idea very probable. It has been objected, that we sometimes find in beds of coal, vegetables that are scarcely decomposed.

It is generally allowed that coal has been produced after the creation of organised bodies; and that previous to its consolidation it has been at least partially fluid, either by solution in water, or by the action of heat under compression: which accounts for its crystalline structure, and often for the contained minerals.

There is a remarkable uniformity in the position of coal and its accompanying minerals, in all parts of the world. It is usually found under a thin layer of shale, which is called the roof. The stratum beneath the coal is called its floor.

Whatever cause produced coal, it has been many times repeated—hence the great number of beds of coal in the same mine, under the same circumstances.

From whatever fluid coal was deposited, that fluid was in a state of rest at the time of the deposition, since the leaves of fern, &c. which are found, are always in an expanded state. Jameson notices a trunk of a tree 40 feet long, rising through a coal formation. At New Castle, one was observed 30 feet long, of which the trunk and large branches were petrified, or become siliceous, while the small branches. the bark, and the leaves, had been converted into coal.

In the coal mine of Treuil, near St. Etienne, in France, "are found a great number of trunks, placed in a vertical position, traversing all the layers of a bed. It is a real forest of monocotyledonous vegetables, in appearance resembling bamboos or the large equisetum, petrified on the spot."

Similar facts have been observed in the coal fields of Scotland, in the mines of Maneback, and in Saxony.

We have large quantities of coal in this country. —Illinois, Missouri, Indianna, Kentucky, and Tennessee have it in abundance. In Ohio there are all varieties of true coal. That of Virginia exists in great quantity. But here we again turn to Pennsylvania, one third of which state rests on coal. The west side of the Susquehannah river, from near the mouth of the Juniata, through all the country watered by the west branch of the Susquehannah and its streams, to Pittsburg, and thence down the Ohio and its streams, contains coal of a good quality. At Pittsburgh it approaches the surface.

It is to be observed that the situation I have here given to our true coal, is different from that assigned to the Anthracite of Lehigh and the Schuylkill.

As this subject has become of great interest, and as much time and money have been expended in fruitless searches for this valuable article, merely from the want of a few simple facts, it may not be improper to notice a few circumstances which we should always have in mind, when coal is the object of our researches.

It may be laid down as an invariable rule, that good coal in sufficient quantity to work, is never

found in primary rocks—as granite, gneiss, &c. so that the idea of coal being found in the Highlands of the Hudson, is without foundation. It is possible that anthracite may be found, but no coal. *

Neither are we to look for coal on Long Island, nor in the low lands of New-Jersey. The Lignite or Bovey coal may exist there, and be valuable: but it is very doubtful if the quantity would be of consequence.

From the position in which I have stated coal to be found, it is evident that at least one edge of every seam of coal must rise, in some place, to the surface: and we must examine all those places where strata have a chance of being exposed, as rivers, gullies, small streams, and ditches; from some of which we will soon learn the possibility of finding the object of our search. White and red sandstone are not always in company with coal—but shale, containing small balls of iron stone, and small thin strata, in the composition of which, and between the layers of which there is the slightest tinge of coal, are never found except near coal fields.

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* While correcting this proof, we have seen in possession of Dr. Dekay, specimens of anthracite, said to be found in this locality.

Though the seam of coal comes to the surface, still it is liable to decomposition, and on that account may be found covered by and mixed with clay, gravel, or sand, in which case, the mass above is usually found to contain small pieces of coal. If these are found in a ravine we may be sure the seam of coal is higher up than the spot where they occur. Sometimes too, the superficies of a coal seam becomes in part dissolved, and presents a black friable bed on the surface; and should this occur on a side hill, it often gradually descends so as to cover a large space, becoming thinner as it descends. This black bed is often found 40 or 60 yards from the real coal—and has often so deceived the inexperienced as to occasion immense sums to be thrown away within a few yards of the coal, especially where the declivity is rapid, as then it is not so easily traced.

It is necessary too to notice the strata of rock, and mark what angle they make with the horizon; and to what point of the compass they run.—Sometimes the coal runs parallel to a gully or ravine for a long distance—and other times crosses it. In the last position it is more readily noticed. In the former, much trouble and cost is occasionally the consequence.

Even when the appearance of coal is found, and is favorable, it requires knowledge and judgment so to dig as to hit the bed. No accurate idea can be formed until the bed is so laid open to view, as to show itself between the roof and floor or pavement. We may then judge of its thickness, as that rarely alters—we may also judge of the purity of the coal, as it sometimes contains stones or pyrites—also if it be hard or soft, or if it will burn well or not. Many beds of coal improve as they descend, and it is generally admitted, that all coal is better, that is found under a greater mass of superincumbent strata.

Shale, or slate clay, or secondary argillite, resembles the argillite already noticed, from which it differs only by its less solid and indurated state. It is formed by the decomposition of older rocks, and is fine or coarse, according to the size of the materials, sometimes even containing fragments or large nodules of rocks.

The texture is shistose, divided by natural joints into beds.

It seldom forms extensive tracts of country, being usually subordinate to more important and conspicuous formations.

It occurs most frequently in very thin strata or laminæ, alternating with other rocks. It is associated with coal, alternating with it, and often impregnated with bitumen. It is found also with secondary limestone, forming thin strata, alternating with calcareous beds, or entering as a constituent.

Its resemblance to greywacke is sometimes so strong as to deceive, without an examination of the geological position.

It often contains many vegetable impressions.

The next rock we have to mention, is limestone; called MAGNESIAN LIMESTONE, or Alpine limestone. It is a dull rock, of various colours, usually greyish, from white to black, which it derives from bitumen. Its texture is usually earthy—rarely crystalline.

This rock is not found in all countries—on the continent of Europe it exists in great abundance, and takes the place of the rock I shall next mention. On that continent it is the usual repository of gypsum and rock salt—two very important minerals. The term Alpine Limestone applied to this rock, is unfortunate, since it offers the idea that the Alps are formed of it: which is erroneous.

The rock salt found in this rock is also always associated with a certain clay, called Muriatiferous clay, which characterises the formation of rock salt, in both hemispheres, as the clay with impressions of fern, does that of coal.

Rock salt is found minutely disseminated in this clay, or forming large masses—and this points out how it is to be worked—whether it is to be worked or quarried—or whether the rock is to be washed by the repeated introduction of fresh water, for the purpose of dissolving the salt, and thus bringing it out in solution. When the salt does not form true beds, it is often found interwoven, as a net work, running through the clay At other times it exists in thin veins. On the eastern declivity of the Andes in a Peruvian province, the river Gualaga has cut its way through the skirt of a mountain of rock salt, which also contains an ore of lead. Indeed, lead, clay gypsum, and limestone, are the usual accompaniments of rock salt.

In Europe and in South America, rock salt is in many places quarried, and is open to day.

Upon comparing the different localities of rock salt in England, at Bex, (Switzerland) on the Carpathian Mountains, of Hallein, of Hallstadt, of Savoy, and of Halle in Tyrol, it has been noticed that the

deposits of rock salt in Eurcpe, diminish in riches with their elevation above the sea. In South America, where alone on our continent, we have yet found rock salt, it occurs in immense beds, nearly 14,000 feet above the ocean: and only one mine, that of Huaura, in Peru, is richer. It is there worked in the same way as a quarry of marble.

This limestone has its peculiar fossils viz. gryphites, entrochites, terebratulites, pentacrinites, arcæ, encrinites, ammonites, orthoceratites, bones of the monitor, impressions of lycopodiaceæ, and bambousaceæ and leaves of dicotyledon plants, analogous to the willow.

In countries where this rock does not exist, as in England, its place is occupied by another—viz.

The Variegated Sandstone, or New Red Marle, which in that, and some other countries, is considered as the peculiar repository of rock salt. In most countries, the salt seems to have been deposited in basin shaped cavities, similar to those in which we often find coal. This is the case with the salt of Cheshire in England, where one bed of hard salt is 26 yards thick. At Cordova, in Spain, where one mass of salt is nearly 700 feet high,

and more than 1200 feet broad, it is encompassed by this rock.

The sandy deserts of Caramania in Asia afford rock salt so hard and dry that it is used as building stone.

Where rock salt is not found, and springs supply its place, it is singular that they are always found in a line, or band, as it were: and usually at or near the base of some mountain chain.

The most splendid and remarkable deposits of salt, are at the foot of the Carpathian mountains—the English mines are near its central chain. and we may draw a line on the west of our Alleganies, beyond which all our salt springs are found. Our own invaluable springs in Onondago, Cayuga, Wayne, and the neighbouring counties are sources of wealth to our state, which are indeed inestimable. In 1800, when the brine of Onondago was supposed to be rich, it afforded but 42,754 bushels—In 1814, nearly 300,000 bushels were manufactured—allowing the state a revenue of $7,000—and in 1823, upwards of 600,000 bushels were made, and the state reaped a revenue of nearly $76,000. In 1824, the tax amounted to nearly one million of dollars. From the town of Salina, above three millions of bushels might be made, should

the demand require it, and the state would derive an income of $375,000 from the brines of one village.

The importance of this article is yet to be discovered by our citizens. The manufacturer and the agriculturalist are yet to be convinced of the benefits it can afford them: to the agriculturalist, in particular, it offers the means of improving his lands, of increasing his stock, and materially enlarging his profits.

The various uses of salt, its localities, the places where it may be found, and the purposes to which it may be applied, have been some months before the public in an "Essay on Salt," to which I may refer you.

Reposing on the Magnesian Limestone or Variegated Sandstone are various beds of lime, under the names of oolite, shell limestone, lias, and marle: and several beds of sand, under the names of ferruginous sand, and green sand.

The SECONDARY LIMESTONE occupies an important place in our country—and covers the immense secondary region embracing the western parts of our state, extending north into Canada, to the primary ridge of mountains dividing the waters

of the St. Lawrence from those of Hudson's Bay, and south to the Ohio.

SHELL LIMESTONE (the Muschelkalk of the German school) is usually the lowest of this class of limestone, and is very similar to the English Portland stone.

It is characterised by the great abundance of broken shells pervading the mass. Humboldt supposes that it has an oolite for a geognostic equivalent. He mentions the following shells as belonging to it—belemnites, chamites, ammonites, nautilites, buccinites, trochites, turbinites, pectinites, ostrocites, terebratulites, gryphites, mytulites, pectacrinites, encrinites, &c.

What has been usually termed the Jura Limestone, is a succession of beds of lias, marl and oolite, of which the former is the lowest. This unfortunate name was given to it by Humboldt.—It is also called the Cavern Limestone.

In England this suite of formations is considered as very interesting, and occcupies the whole space between the variegated sandstone, or new red marle, and the chalk. It is there found to contain several sub-divisions or beds, each bearing a different name.

Lias reposes, in many places, on the new red marle; it is a blueish argillaceous mass, alternating with beds of limestone. These beds become thicker towards the lower part, white, and fit for lythographic purposes. The fossils of the lias are numerous and beautiful. The following list approaches to a perfect catalogue so far as we know, viz.—Ichthyosaurus, plesiosaurus, testudo, several species of fish, ammonites, (about 20 species) those having the siphuncle in an elevated ridge, between two furrows are characteristic of this formation.

Nautilus, scaphites, belemnites, helicina, trochus, tornatilla, melania, dentalium, patella, modiola, unio, cardita, astarte, arca, cucullæa, nucula, terebratula, spirifer or pentamenus, gryphœa, ostrea, pecten, plagiostoma, lima, plicatula, hyppopodium, perna? echinus, crinoidea: the following species of this genus, pentacrinite, caput medusæ, briareus, subangularis, basaltiformis, tuberculatus: many remains of wood, fern, &c. and a species of turbinolia.

The most characteristic shells of this formation are the ammonites, (bucklandi) the gryphœa, (incurvata) and the plagiostama, (gigantea.)

The OOLITES or *Roe Stones* derive their name from the small particles embedded in the mass, giving it an appearance similar to the roe of fishes. The principal building stone of England is from oolitic series.

Oolite has lately been found in our country.—Mr. Schoolcraft noticed it regularly stratafied, in the State of Illinois, as containing lead mines, in connection with shell limestone. A locality of it has been noticed in Saratoga county during the last summer. As yet no geologist has thoroughly examined this rock in situ in United States.

The great mass of oolites in England has been sub-divided, into three distinct systems, each of which has been separately studied and found to be rich in organic remains. They are separated by beds of clay.

The Lower System or Division of Oolites, consists of oolite mixed with sand, and fullers' earth, and embraces the great oolite, oolite of Stonesfield, cornbrash, forest marble, and Kelloway rock, of the English Geologists, and the shelly, and arenaceous limestones. The following are the contained fossils; Saurian animals, two or three species of testudo, several of fish, two or three of insects, crustacea, ammonites, nautilites, belemnites, trochus, voluta, turbo, turritella, rostellaria, ampullaria, natica,

ancella, planorbis, melania, helicina, serpula, modiola, unio, trigonia, cardium, cardita, mya, venus, lutralia, astarte, fistulana, mytilus, donax, tellina, pinna, ostrea, pecten, avicula, lima, terebratula, chama, plagiostoma, gryphœa, perna, crenatula; echinus, encrinites, coralloids and alcyonia; also fossil wood and vegetable impressions.

The Middle System or Division of Ooolite, embraces Oxford clay, (clunch clay) sand, calcareous conglomerates, (calcareous grit) coral rag, or limestones with madrepores and echinites—and contains the following fossils, viz.—bones of the ichthyosaurus, ammonites, nautilus, belemnites, melania, turbo, helix, trochus, rostellaria, patella, serpula, ostrea, pecten, cardita, chama, gryphœa, trigonia, lima, lithophaga, mytilus, modiola, avicula, plagiostoma, terebratula, echinus, clypeus, caryophillia, astrea, and fossil wood.

The Upper Division of Ooolites contains the clay of Kimmeridge, blue and a little bituminous, the Portland stone, Purbeck stone, argillaceous limestone with shells, alternating with marl and gypsum.

The list of fossils follows—Ichthyosaurus, plesiosaurus, cetacea; several species of fish, ammo-

nites, nautilus, belemnite, turritella, natica, solarium, trochus, turbo, melania, ostrea, astarte, crenatula, pecten, trigonia, venus, modiola, lutralia, cardita, cardium, mactra, tellina, chama, nerita, unio, avicula, cyclas, terebratula, serpula.

The ammonite triplicatus, and pecten lamellosus are most characteristic of the Portland oolite; and the ostrea deltoidea of the Kimmeridge clay.

The beds above the oolite are iron sand, green sand, and chalk marle, running into chalk, the last of the secondary rocks, approaching upwards.

The IRON SAND FORMATION, is composed of a series of strata of sand, and sandstone, occasionally alternating with small beds of clay, loam, marle, fullers' earth, and ochre. The sand and sandstone are siliceous, and coloured by oxide of iron—a metal existing in such quantity in this formation as often to render it worth working. This seems to spread extensively over the western parts of the state of New-York, and to be noticed by Mr. Eaton,(in the survey of the district adjoining the Erie Canal, which Gen. Van Rensselaer employed him to take,) as the ferriferous sand rock. In England it is occasionally 1000 feet thick, and worked in many places for iron, the most abundant mineral of this rock.

The organic remains are not numerous: a nautilus, fragments of ammonites, belemnites, ostreæ, terebratulæ, spines of the echinus, spongitæ, and corallines.

Green Sand is composed of Siliceous sand, loose, and united in form of sandstone, by a calcareous cement, and containing small particles of green earth, whence is derived the name. The size of the grains varies from very small, forming a fine grained sandstone, to large, forming a conglomerate rock. It is usually divided from the iron sand by a dark blueish clay, containing small specks of mica, with nodules of selenite and iron pyrites.

The fossil contents are beautiful. A few teeth of fishes have been found, and upwards of 150 species of testacea—the following may be ennumerated: ammonites, nautilites, hamites, turrilites, belemnites, varieties of helix, trochus, solarium, turritella, murex, natica, pleurotoma, rostellaria, auricula, ampullaria, planorbis, turbo, vivipara, serpula, dentalium, vermicularia, patella, arca, cucullæa, nucula, trigonia, pecten, pectunculus, terebratula, cardium, venus, cardita, dianchora, corbula, chama, ostrea, inoceramus, mya, modiola, perna. The echinus in several varieties, resembling; but different from, those found in the chalk.

The encrinital remains are few, the coralloids scarce and unimportant. The remains of Alcyonites are numerous and beautiful. No vegetable remains, but fragments of silicified wood.

Many of these interesting fossils have been found in some of our southern states. The region in the vicinity of the Potomac has afforded many beautiful specimens for the cabinets of our different societies and of individuals.

By alternations of sand with argillaceous and cretaceous beds, until the latter prevails, the greensand passes gradually into a chalky marle. It differs from chalk by its grey or mottled appearance, and its lamellated texture. It is more gritty than chalk, and will not mark. The upper and more cretaceous beds, next to the chalk, contain fossil remains, similar to those found in that rock, viz. nautilus, inoceramus, echinus, alcyonia, and spongia. The lower beds, which are also more argillaceous, have their peculiar fossils; those peculiar to, and characteristic of this formation, are the ammonites, mantelli, minutus, planicosta, rostratus, splendens, variens: the nautilus, inæqualis elegans, comptoni. Hamites. The other remains are scaphites, turrilites, belemnites, dentalium, vermicularia, cerithium, euomphalus, patella,

terebratula, arca, nucula, pecten, inoceramus, echinus, zoophytes, pentacrinite.

The rock next in order is CHALK, into which the one last mentioned easily passes, by almost imperceptible gradations, forming at first the chlorited chalk, (glauconie crayeuse, of the French) having small grains of chlorite sparingly intermixed; then the coarse chalk, (craie tufau) greyish and sandy, containing some marl and hornstone, instead of flint, and finally the white chalk, the purest of limestone beds, containing only 1 or 2 pr. ct. of magnesia, with more or less sand.

In Europe, the Chalk forms an extensive and interesting formation in what is called the great central basin of Europe, which is bounded as follows: On the North by the primitive ridges of Russian Finland, Sweden, Norway and Scotland; on the West by the chains of Cumberland, Wales, Devonshire and Brittany; on the South by primary mountains in the centre of France, the Alps, and the various insulated groups of Germany, &c. as the Black Forest, the Rhingau, and the Vosges, the Bohemian, Thuringian, Saxon, Silesian, and Carpathian Mountains; and on the East by the Ural and its branches. In this great tract, thus circumscribed, is another resting on chalk.

Chalk in the upper beds, invariably embraces nodules of flint in great abundance. Iron pyrites exists in all the beds.

The organic remains are confined to few genera, but many species; teeth of the shark, ammonites, scaphites, belemnites, trochus, cirrus, turbo, serpula and spirorbis, ostrea, pecten, terebratula, magas, plagiostoma, dianchora, inoceramus, balanus, echinites. These last are considered as characteristic of chalk, and equal in number all the other remains: one genus, and many species are peculiar to it. Of the astrea there are several species. Of the zoophytes, the encrinus has several genera in the chalk. The alcyonia and spongia are numerous. The remains found in chalk in England and on the Continent of Europe are similar, and preserve their analogy through all the different beds. In the most ancient, the bones of the monitor, of sea turtles, and teeth and vertebræ of fishes are every where found.

The chalk formation has not yet been discovered in our country, and some deny its existence. It is presumption however in any man to assert that it is not to be found: thus far the search for it has been unsuccessful; but when Geologists shall more thoroughly examine the structure of our continent, it surely is not too much to say, that

is very possible this rock may be found. But even should it never be discovered, the geological chain is still unbroken.—We are not to expect precisely the same rocks in all countries, nor are we even to expect geognostic equivalents for every individual rock that may be absent—since, as has before been stated, upon high authority, one formation may represent many others. At any rate, Chalk must retain an important place in all systems or outlines of Geology.

It forms in Europe a very remarkable and conspicuous formation, and because we do not find it on our continent, are we therefore to discard it from systems? As well might we, in treatises on governments, discard the despotic, or the monarchical, because in the United States, we find only the republican. No individual should arbitrarily introduce new names into any science, without the most profound study and reflection upon the consequences : nor has any one the priviledge of discarding certain terms upon his own authority. Most persons are willing enough to listen to and examine proposed or suggested novelties, which may be correct, or not. It is perhaps better to retain an old name that is not strictly scientific, than to deluge us with new terms to

perplex the student without gaining any other object.

It will be observed that the Secondary Rocks compose an extensive and valuable portion of our Union. The country of the Mississippi, which is but a portion of an immense region of valley or flat country, that extends from the Gulph of Mexico, north-easterly to the Atlantic, and north-westerly to the Pacific Ocean, is of secondary formation. Extending for hundreds of miles, it enjoys at one extreme the brilliant sunshine of the south, and at the other the frozen rigors of winter. It possesses a fertile region. decked with all the beauties of vegetation, and offering the choicest grains and fruits and flowers to the occupant. The mild beauty of its elevations, crowned with oak and ash and hickory, the luxuriant fertility of its vales bearing abundance of grain, and watered by large and picturesque rivers, presents to us some of the finest and sweetest scenery of our country.

As no section of our Union is more productive than our Secondary, so none is more blessed with contentment, and prosperity.

Its soil is fertile, and its rocks rich in treasures.

The Tertiary Formations commence where the Secondary ends, viz. at Chalk. It may be considered as a good rule, that all rocks older than the old red sandstone, are primary—all those between the red sandstone and chalk are secondary, and those above chalk, tertiary. Volcanic rocks and Alluvia are of separate and distinct classes from each and all others.

The tertiary formation is composed of different compounds, in which lime and sand and clay are the chief materials. It is but a few years since these strata have been separated from the alluvia. It was first noticed in the vicinity of Paris that they were too large and regular to be of alluvial deposit, and the researches of Cuvier and Brongniart established them as belonging to a new class of formations. The accurate observations of Mr. T. Webster,* then occupied in making drawings for the splendid work of Sir H. Englefield on the Isle of Wight, soon determined that the beautiful island was not only of tertiary formation, but that it was precisely similar to the tertiary

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*The accuracy of this accute Geologist has lately been questioned in one of the most learned periodical journals in England. But it must be evident to Geologists that the author of the attack (Dr. Fitton) is often in error, and contradicts himself, so as in a great measure rather to corroborate the statements of Mr. Webster, than to disprove them.

formations of France. To this gentleman and to Mr. Buckland we owe the first scientific description of these formations in England.

The North of Germany, to some distance from the shores of the Baltic—the great valley of Switzerland, near the Lake of Constance—some of the Subappenine hills in the valley of the Po, and accompanying the shores of the Adriatic to Otranto—Sicily, Dalmatia and parts of Greece exhibit similar beds, in which we find the same fossils and the same compounds.

This class is remarkable for the beauty and variety of its organic remains.

As these formations are composed of an indefinite number of strata succeeding each other without any very determinate order, we are naturally led to expect a diversity of combinations and names.

The first division of this class was made by Cuvier and Brongniart, who enumerate the following in France.

Plastic clay, with sand, (*argile plastique*) fresh water deposit.

Coarse marine limestone, (*calcaire grossier,*) with marine sandstone, or (*gres marine infereur*) marine deposit.

Siliceous limestone, (*calcaire silicieux*) not ascertained.)

Gypsum and marle containing bones of animals, (*marnes du gypse d' ossemens*,) Fresh water and marine.

Marine marl, abounding in bivalve shells; the superior layers containing oyster shells in abundance. (Marine.)

Sandstone and sand, without shells, (not determined.)

Upper marine sandstone, (*gres marine superieur*) marine.

Millstone or Buhrstone without shells, (*muliere sans coquilles*,) not determined.

Upper fresh water formation, millstone, flint, and limestone, (*terrein d'eau douce superieur, meuliere silex et calcaire*,) Fresh water.

These are supposed to be alternate deposits from the salt water of the ocean and of fresh waters of lakes.

The plastic clay rests on the chalk. It is white, grey, yellow, red and black, containing a layer of sand, and a few very organic remains. The clay is tenacious, unctuous, and slightly siliceous, and is used in the manufacture of pottery and porcelain. The sand has all varieties of color.

The coarse marine limestone and marine sandstone composed of several distinct strata. The first a coarse sandy limestone containing green particles, and many shells retaining much lustre, and differing from existing species. The following are enumerated: nummulites, madrepora, astrea. Caryophillia, fungites, cerithium, lucina, cardium, voluta, crassatella, turritella, ostrea.

The second, greyish yellow limestone, partly oolitic, and containig cavities filled with loam, sand, and flint. It contains nearly all the 500 different species of bivalves found at Grignon: the following shells may be mentioned cardita, orbitolites, turritella, terebellum, calyptrea: pectenculus, citherea, miliolites, cerithium.

The third is less abundant in fossil varieties—miliolites, cardium, lucina, ampullaria, cerithium, corbula. The second and third sometimes embrace a sandstone containing, among others, the following shells—calyptræa, oliva, ancilla, voluta, fusis, cerithium, ampullaria, nucula, cardium, venericardia, cytherea, venus, lucina, ostrea.

The fourth embraces marls, hard and soft, and calcareous sand, occasionally agglutinated, and containing layers of hornstone, and crystals of quartz, calcareous spar, and fluor spar, with very few fossils.

The siliceous limestone without shells occurs always in the same level, and alongside of the preceding. It consists of strata of white limestone. and of grey, or compact, or granular limestone, penetrated by silex, which, in different shapes, fills the cavities. It has no fossils. It seems to be only a part of the preceding rock.

The gypsum formation, and the marine marl formation, are treated of together: being gypsum, and beds of clay marl and calcareous marl, in a regular succession, when all are present. The gypsum constitutes the greatest mass, occurring in longish or conical bodies, and not in extensive fields. Montmatre, in Paris, is an example, and there three beds are placed over each other. The first, contains alternate layers of gypsum. calcareous marl, and argillaceous marl: sea shells are found in it—as are fresh water shells in the white marl. The second has more beds of marl than the first, and contains sulphat of strontian and fossil fishes. The third is the most extensive, and contains many beds of marl. The quarries in this upper gypsum afford those remarkable skeletons and bones of unknown birds and quadrupeds. The following fossils are found in these united formations. Palæotherium, magnum, medium,

crassum, curtum, and minus. Anaplotherium, commune, se cundarium, medium, minus, minimum. A pachidermatous animal allied to the hog. Canis parisiensis. Three or four species of birds. Trionix parisiensis, and another tortoise. A saurian animal, allied to the crocodile. Three or four species of fishes. Cyclostoma,limneus,planorbis, spirorbis, cerithium, cytherium, ampullaria, cardium, nucula, ostrea, cancer.

Sandstone and Sand without shells rests on those already described, in strata of considerable thickness.

The Upper Marine Sandstone and Sand varies in composition, and color and compactness, being a greyish, or red sandstone, sometimes argillaceous, sometimes calcareous. This sandstone contains fossils differing from those found in the sandstone formerly mentioned, viz. olivia, cerithium, pectunculus, crassatella, donax, citherea, corbula, ostrea, melania ? fusus ?

Millstone without shells embraces millstones, sand, iron shot, and a clay marl, greenish, reddish, or whitish. It seems to be only a portion of the following division. The millstone is a quartz with

many irregular cavities, traversed by reticulated siliceous fibres, and sometimes filled with ochre, clay or marl. There are no organic remains in the millstone.

The Flint and Siliceous Limestone Formation consists of these two substances, independent of each other, or intimately united. The limestone most common is nearly pure, often embracing flint, of which however large masses are rare. The limestone is white or yellowish, and whatever may be its original hardness, it softens by exposure, and forms a manure for the agriculturalist. The essential character of the formation is the contained multitude of fresh water and land shells, nearly all of which belong to genera now inhabiting morasses; but no marine shells, except when in immediate contact with the marine formation. The following belong particularly to the upper fresh water formation. Cyclostoma, potamides, planorbis limneus, bulimus, pupa, helix, dycotyledons silicified, arundo. No bivalve occurs among the number.

It has been justly observed that the Plastic clay, limestone, gypsum, sandstone, and flint and siliceous sandstone, seem well characterised; and that

the terms fresh water and salt water formations might perhaps be supplied by more appropriate names. The hypothesis whence these names are derived seems supported by the organic remains of the strata.

Of the *Tertiary Formations in England* we have an elaborate description by Messrs. Conybeare and Phillips. They name four, viz. the Plastic sand and clay, resting upon which is the London clay, and over this the fresh water formation, and the upper marine formation.

The Plastic Clay is formed of an indefinite number of beds of sand, clay and gravel, alternating without order. Mr. Webster remarked the similarity of this formation to that of Paris. The sand of Alum Bay, in the Isle of Wight, exhibits every variety of color. The clay is laminated, and of various colors and purity, offering the several kinds of clay for the arts. There are few minerals: iron pyrites, selenite, gypsum, and a few spangles of mica. The organic remains are not numerous nor regular, being found indiscriminately in the clay, sand, and pebbles. The following are the usually contained fossils, murex, infundibulum,

cerithium, turritella, planorbis, astrea, pectunculus, mya, cytherea, cyclas.

The London clay is so called from its forming the substratum of London and its environs. It is a tough, bluish or blackish clay, varying in its characters; some strata partaking of the nature of marl. The lower parts frequently run into a siliceous sandstone.

It may be stated to be an extensive, argillaceous deposit, embracing subordinate calcareous beds, occasionally passing into solid rocks, or varied in aspect by an accidental mixture of sand and calcareous matter with the clay.

In its relations and fossils this is supposed to approximate nearly to the *calcaire grossier* of Paris. It contains iron pyrites, amber, selenite, and lignite with the woody fibre.

The fossils are interesting and numerous. The crocodile and the turtle, and several species of fish are found. Zoopytes are rare. The vegetable remains are numerous and beautiful. In the island of Sheppey alone upwards of 700 varieties of fossil fruit have been observed. The following shells are mentioned viz: ammonites, nautilites, nummulites, seraphs, cyprea, conus, terebellum,

auricula, voluta, oliva, ancilla, buccinum, melania, cassis, murex, pleurotoma, fusus, rostellaria, strombus, cerithium, infundibulum, trochus, solarium, turritella, turbo, scalaria, ampullaria, vivipara, natica, ostrea, pecten, pectunculus, avicula, modiola, nucula, arca, chama, mya, lingula, solen, cardium, cardita, isocardia, venericardia, venus, corbula, serpula, dentalium, teredo.

The fresh water formation, in general terms, consist of marle, argillaceous limestone, and sand, crossed by calcareous spar. It contains no gypsum, which is so plentiful and abundant in remains, in the French corresponding beds. This formation has been seperated into the upper and lower divisions.

The latter consists in a series of beds of sandy, argillaceous, and calcareous marls, containing a coaly matter. Some of them seem to be wholly composed of comminuted fresh water shells, contaimining some that are entire, among them are the lymneus, planorbis and cyclostoma, helix? and mytilus?

The upper division is an extensive calcareous bed, of yellowish white marl, that is soft, but includes harder and more durable masses. It contains veins of cabonat of lime--The organic contents

are found in all parts of the bed, and consist exclusively of fresh water shells, as lymneus, planorbis, helix. Some seeds are found, and parts of coleopterous insects.

The other shells found in the entire formation are potamides, paludina, melanopsis, phasianella ? ampullaria, unio.

The upper marine formation is composed of sandy and gravelly deposits enclosing fresh water shells, and sometimes embracing beds of shell marle.—The sand is sometimes ferruginous, and cemented. It resembles the corresponding formation of France. It contains no minerals. The following fossil are mentioned. A large tooth, fragments of bones, spongia, alcyonia. Most of the shells are recent. Patella, emarginula, calyptrea, buccinum, murex, cassis, natica, turbo, cyprea, scallaria, turritella, vivipara, voluta, trochus, infundibulum, mya, unio, lingula, mytilus, cardium, venericardia, venus, arca, astarte, mactra, solen tellina, nucula, balanus, pholas, dentalium.

Of the *Tertiary Formations in the United States*, the most extensive is the *Plastic Clay*, exhibiting its brilliant clays and sands, with its beds of peb-

bles, and its lignite. At Martha's Vineyard, where it has been examined by Mr. Hitchcock, it presents cliff 200 feet in height, composed of an irregular succession of beds of clay, sand and pebbles, with lignite. The clays are white, brown, blackish, red and yellowish of many shades. The sand too has various colors. The pebbles have a ferruginous coat—The lignite is well characterised. There occur small plates of silvery mica, and a small and occasional quantity of amber. The subtratum is not known.

On Long Island this formation is well marked, and there is scarcely a man on the island but knows that at the depth of from 15 to 60 feet *charred wood*, with perriwinkle and other shells are found in beds of clay, sand, and gravel.

Large quantites of clays are annually sent from Amboy, (New Jersey,) and their use in manufactures is well known. The whole triangle formed by the Ocean and the Delaware and Raritan rivers is composed of sand, clay and gravel, alternating, and occasionally consolidated by a ferruginous cement. It contains lignite and shells. The banks of the Delaware river, for several miles, are composed of brilliant sands, with beds of clay and lignite: the clay is white, yellow and blue, with shades. This formation extends southward, skirt-

ing the Atlantic through our southern states. It has been examined at various points, and presents the same characters at Martha's Vineyard, Long Island, Staten Island, New Jersey, near Philadelphia, at Cape Sable, and in Florida.

Its similarity to the English and French Plastic clay is acknowledged now by all those who have kept pace with the rapid strides of Geology for the few last years, and who are willing to examine facts without reference to theories. The following fossils have been found. Murex, venus, cardium, pectunculus, ostrea, arca, pecten, donax.—teeth of sharks, crocodiles, and cetacea.

The *London Clay*, or a corresponding formation has been supposed to exist at Washington, and to form the general substratum of the city. It was noticed and mentioned several years ago, as a muddy clay, containing occasional pebbles and shells—with trunks and branches of trees resembling coal, and with iron pyrites. The teeth of sharks and a large rib were many years ago taken from the clay. Mr. Finch has compared it to the formation of Highgate near London.

The coarse marine limestone (calcaire grossier) and *the siliceous limestone* (calcaire silicieuse) seem to

exist in Georgia, judging from the millstone or buhr stone sent from that state. In some parts of this formation are cavities are filled with stalactites or incrustations—in other places it abounds in shells, among them mactra and tellina have been observed, with madrepores and a pectunculus. Hornstone and quartz are found imbedded. The calcaire grossier has been observed by Humboldt in So. America, and there contains ostreæ, madrepores and turbinites.

In New Jersey are several localities of a clay nearly filled with shells—or perhaps more correctly of large masses of shells with clay. They rest on gravel beds; and are used as manures, under the name of marl. These beds are immediately under the soil, and afford the remains of the mastodon, the crocodile, the shark, the monitor and cetacea: pectens, terebratulæ, donax, arca, turbinolia, rostellaria, ammonites, pyrula; also lignite and amber. Similar localities exist in the counties of Orange and Ulster where bones of the Mastodon have been found: the pecten, ostrea, venus, planorbis, helix, and voluta.

This seems to correspond with what is termed by the English Geologists, the upper fresh water formation.

An interesting account of these formations will doubtless soon be published by those who have had more extensive opportunities and leisure to examine them. From a collection of shells lately made in Maryland, the following have been described in the Journal of the Academy of Natural Sciences at Philadelphia. Turritella, natica, oliva, buccinum, fusis, fulgur, calyptrœa, dispotoa, fissurella, ostrea, pecten, plicatula, arca, pectunculus, nucula, venericardia, crassatella, isocardia, tellina, lucina, venus, cytherea, astarte, mactra, amphiderma, corbula, panopœa, serpula, dentalium. In Europe the isocardia has, I believe, been found only in the London clay; and the astarte in the upper marine formation: should these be considered as characterestic, this collection of fossils would indicate their positions to have been the Plastic clay, London clay, and upper marine formations.

The siliceous sand of the upper marine formation, shifting with every wind that blows, is seen on many parts of Long Island, in New Jersey, Virginia and the Carolinas.

In fine, the whole tract of country, with few and small exceptions, between the Allegany ridge and the ocean is of tertiary formation. Commencing, certainly as far north as Martha's Vineyard, per-

haps even embracing the gypsum and sand of Nova Scotia, it extends through Long Island, and New Jersey, and stretching through our Atlantic States, forms a class corresponding in size with our gigantic primary and secondary.

Some certain rocks are usually referred to a peculiar class, under the term SUPERINCUMBENT or OVERLYING ROCKS. They are unstratafied, and posterior to the rocks in connection with which they are found. They pass almost imperceptibly into each other, with a few exceptions that scarce deserve notice. It may be said that they occur as recent secondary rocks; some of them are of older origin, but there are no unexceptionable rules for distinguishing them, and it is perhaps best to class them together. This is the more necessary as neither composition nor position authorize the distinction of separate families.

The rocks of this division occur in more or less extensive localities; and are by some considered as independent formations. While other geologists suppose them universal, as they are found forming tracts in all countries.

They are observed in contact with every rock from granite to the most recent secondary. We do

not know if they ever rest on the tertiary; they have not been noticed in that position.

In granite they occur in veins. In the stratified rocks of both primary and secondary classes they appear as masses also, and sometimes even as beds. It is said that in the Isle of Skye they form strata parallel, and not connected with veins, but alternating with jasper, siliceous schist, and ferruginous clay.

These rocks sometimes constitute mountains, or hills; and sometimes form the summits merely. Mount Holyoke, Mount Tom, East and West Mountains, near New Haven—and the superb Palisadoes on the Hudson river are familiar examples.

They sometimes resemble granite, being disposed in beds, and divided into cuboidal masses, which occasionally become rounded by the weather, in the same way as that rock.

They are sometimes also prismatic and columnar; of which the Island of Staffa, and the Giant's Causeway are among the most splendid examples. The columns may be regular, and in contact: or they may be irregular in the same bed: sometimes they are so confused as to resemble a mere heap of broken columns. In many instances the prisms are straight, and in contact, thus bestowing a beautiful architectural appearance; as in Fin-

gal's Cave. In some instances the prisms are bent, in one or more directions.

The form of the columns varies from three the twelve sides—which are often so placed as to present an absolute whole, marked by lines. This structure occurs in all the members of the family—not in basalt only, as is frequently supposed, but in sienite, claystone and greenstone.

The laminar structure occurs in this family : the laminæ varying from the thickness of paper to very large. This structure is found in all varieties of these rocks. The laminæ are parallel, or transverse to the columns, when combined with the columnar structure.

There is a peculiar internal structure in these rocks, exhibited by decomposition. It is often the case that a column or joint wastes away, so as to show, by successive exfoliation, a spheroidal figure.

Sometimes, some of those varieties having a base of indurated clay, become changed, by disintegration to some depth, and are so soft as, by many, to be mistaken for clays.

The cavernous, amygdaloidal and porphyritic structures, are also seen in these rocks.

The cavernous is similar to the variety occur-

ring in some lavas—the cells being elongated, or contorted, and coated with a vitreous varnish.

Occasionally the cells contain those substances that are found in the amygdaloids ; thus these two structures sometimes pass into each other, sometimes into the porphyritic.

There are so many rocks in this class that we cannot give any general rules as to texture or composition.

Indurated clay is the chief substance in this family, passing into claystone, clinkstone and felspar : the extremes of this series are essential ingredients. Of the less frequent constituents, hornblende is the most common—varying in quantity and in the size of the crystals.

In sienite, hornblende forms a small share of the rock and is sometimes crystallised. In greenstone it is very minute and confused: when it is very abundant, and minutely divided, the rock passes into basalt. When most excessive and fine, the basalt is well marked : but there are great differences of aspect. When the base of compact felspar or clinkstone becomes very dark, and the hornblende nearly disappears, the mass passes into clinkstone : and thus many dark clinkstones are termed basalt : thus accounting for the endless variety of basalts mentioned by authors.

The presence of hornblende thus constitutes the series of sienite, greenstone and basalt, also called trap rocks, of the superincumbent class. But there are no characters for distinguishing invariably the two latter. In each the base is claystone, clinkstone, or compact felspar, united by hornblende, and exhibiting a similar structure. The distinctive character chiefly relied on at present is color: those rocks in which the constituents are pale whitish, yellowish, or reddish, being sienite: and those in which they are grey, greenish, or dark colored, being greenstone. Dr. Macculloch proposes that instead of color the quantity of the ingredients be taken as a guide: the excess of the three minerals abovementioned to constitute sienite; and those compounds into which hornblende enters in equal or greater proportion to be named greenstone. But even in this case there will often be doubt as to the nature of some rocks.

Another mineral often forming an ingredient in this class, is augit, which is supposed to have been often mistaken for hornblende. It occurs in the same manner as that mineral, usually of a dark green or black color. It is sometimes sparingly present, and then the compound resembles sienite: at others it so finely divided that the rock

seems homogeneous, and can scarcely be distinguished from basalt. It has been proposed to give to such rocks the compound name of augitic sienite, augitic greenstone, and augitic basalt.

Hypersthene is also mentioned as an ingredient, often compounded with hornblende, of which it is a species.

Felspar is an ingredient in the porphyries. and gives to this rock its peculiar character: but it occurs also in sienite and greenstone without attaching to them the porphyritic structure. In these cases the structure is granitic. Occasionally the felspar is of the glassy variety, sometimes crystallised, at others simply occupying the place of common felspar.

Mica is rarely found in porphyries: still rarer in greenstone. Quartz too is found in greenstone and porphyry—in the same way that it occurs in granite, from which these compounds are sometimes difficult to be distinguished.

The minerals found in these rocks are mesotype, prehnite, stilbite, epidote, calcareous spar, and a very few others occasionally.

For a more full account of the sub-divisons, I refer to the synopsis of these rocks at the close of the volume. As much difficulty has arisen in dis-

tinguishing the members of this class, I have deemed it adviseable to give the synopsis of Dr. Macculloch with slight omissions, as it may aid enquirers in their researches on this class.

The history and formation of ALLUVIAL DEPOSITS is extremely interesting. I have already slightly noticed them. They occur in various situations, bespeaking different origins.

When found in vallies, through which rivers run, they usually arise from the abrasion of the channels in which these flow: and particularly from hills whence their sources are derived. They arise from the same cause when they form extensive plains, accompanying the estuaries of rivers: or when filling lakes: we often see these in the interior of countries where the lakes have been gradually filled with alluvial, and dried up

The waters of some rivers and lakes hold lime in solution, which is gradually deposited—this is the well known Travertino of Rome; and perhaps the stalagmitic rocks of Gibraltar and elsewhere.

On sea shores the waves cast up loose materials formed of sand and fragments of shells, on which

plants grow and add a soil towards the completion of a bank, that eventually rises far above the water.

At the foot of mountain alluvial is formed by the daily waste of the materials, urged solely by the force of gravity, and the ordinary drainage of the surface.

Occasionally rocks are entirely decomposed in situ. The mass of constituents thus crumbled together, lie loose—and are mostly formed of granite, gneiss, or red sandstone.

Thus we have announced four kinds of alluvia, viz. that of rivers and estuaries, marine alluvia, alluvia of descent, and untransported alluvia.—Their extent, depth and form are various. A distinct stratafication is often observed. The particles are of all sizes. sometimes fine as sand, and sometimes many cubic feet. If they are round or angular depends on the distance they have been transported, and on the time and degree they have been exposed to the several causes of waste, and on the nature of the materials.

I have mentioned before, that they often contain minerals, of which tin, gold, and diamonds are the most remarkable.

From the partial alluvia, which we can trace and account for, we must separate the Diluvia, found in places where none of the cause abovementioned could have acted, and which owe their origin, in some cases, to partial and temporary floods; in others to that great and eventful deluge described by Moses, with whose account, as we have seen in a former lecture, so strongly coincide the dicoveries of geology, which has thus rendered an unexpected and important, though unneeded. support to the Sacred History.

We have thus surveyed, with a cursory glance, the different geological theories accounting for the present appearance of our globe.—We have seen that they all refer to that general deluge which forms so conspicuous an epoch in the history of our planet. We have observed that the great waters covered our earth—and have noticed its gradual subsidence, or the elevation of the land. We have seen the retiring waters forming vallies—have followed the divisions of land—and examined the Alpine district of mountains, the lowland plains, and the bottom of the sea.

We have also examined, at least mentioned, all known rocks—from the primary, formed before the

existence of animal or vegetable organization, to the secondary, which contain the organic remains of generations passed away, and which have been termed the medals of nature :—to the tertiary which was last produced, and the alluvia that is daily deposited at the present.

We have also noticed the causes now operating, and changing the surface of our planet, viz. the action of the elements, water more particularly and the formation of peat and of coral reefs, and have examined the agency of volcanoes and earthquakes. And in so doing, have superficially traced the outlines of geological science. The description and history of the various mineral contents of rocks do not come within my duties, but belong to mineralogy.

Should I be asked for a book of reference containing the elements of geology, I must answer that I know of no work that is fit for a beginner in the study. Humboldt, Macculloch, Conybeare and Phillips, and Bakewell, all presuppose too much—and are calculated for the perusal of geologists, rather than students. Their works however may be advantageously consulted. The various periodicals of the United States contain more or less information on this subject—among others I cannot refrain from noticing a little and unpretending pamphlet

occasionally published. "The Annals of the Lyceum of Natural History, of New-York," a society that is actively and honorably engaged in examining and elucidating the natural history of our country. Nor can I omit to mention the Journal of the Academy of Natural Sciences of Philadelphia: Nor the American Journal of Science, so ably conducted by Prof. Silliman.

I am as sensible as any of you can be of the deficiencies and imperfections of this course: but I make no apology, conscious of your being all aware, that no subject, no scientific subject, can be properly treated of and condensed into four or six lectures.

We might have passed our hours with more amusement, but then we must necessarily have departed from the dry detail of this science.

I regret that more time was not allowed to enlarge upon and illustrate the real value and utility of this science. And if in my Lectures I have failed to render the study of Geology interesting, I have the candor to acknowledge, and sincerely wish you all to believe, that the fault lies not in the subject, but in the person who has the honor to address you.

To facilitate the study of Geology, a Synopsis of each individual Rock is here added, affording a view of the different compounds that may be classed respectively under each head.

SYNOPSIS OF GRANITE.

First Division.

Of two ingredients.

A. Felspar and mica.

B. Quartz and felspar.

a. An uniform mixture of these ingredients.

b. The quartz, or felspar, or both, imperfectly crystallised, and influencing each other's forms. Graphic granite.

C. Quartz, and hornblende.

D. Felspar and hornblende.

a. Large grained, or the hornblende crystallised.

b. An uniform granular mixture: the ingredients varying materially in their sizes and proportions.

c. Intimately mixed, so as to be nearly undistinguishable.

Second Division.

Of three ingredients.

A. Quartz, felspar and mica.

a. An uniform mixture of the ingredients.

b. The same with additional crystals of felspar embedded, porphyritic granite.

c. With two kinds of felspar, the common and glassy.

d. The quartz, or the felspar, or the mica, or all of them crystallised.

B. Quartz, felspar and hornblende.

a. Large grained. The sienite of some mineralogists.

b. Small grained, and, like D. *b.* div. 1st, often resembling the greenstones of the trap family, by which name some mineralogists have also distinguished it.

C. Quartz, felspar and actynolite.

D. Quartz, felspar and chlorite.

E. Quartz, felspar and talc.

F. Felspar, hornblende and mica.

This variety occurs in the same manner as D. div. 1st, but is rare.

Third Division.

Of four ingredients.

A. Quartz, felspar, mica, and hornblende: the

sienite of some writers. It passes into var. A. div. 2d, or into common granite.

B. Quartz, felspar, mica, and compact felspar. This is similar to the foregoing, the last substance being accidental.

C. Quartz, felspar, mica, and actynolite.

D. Quartz. felspar, hornblende and chlorite.

E. Quartz, felspar, hornblende and steatite.

F. Quartz, felspar, mica, and porcelain clay.

SYNOPSIS OF GNEISS.

First Division.

Of regular composition, containing at least three of the four minerals, quartz, felspar, mica and hornblende.

First Sub-Division.

Granitic, large grained, resembling granite.

A Quartz, felspar, and mica.

B. Quartz, felspar and hornblende.

C Quartz, felspar, mica and hornblende.

Second Sub-Division.

Schistose, fine grained.

A White felspar and quartz, in minute grains intimately mixed, with rare scales of mica. The position of the mica determines the foliated structure, often so indistinct that this variety is mistaken for quartz rock.

B. The same compound with mica in abundance resembling micaceous schist.

C. The mica so abundant as to form continuous laminæ; sometimes mistaken for micaceous schist.

D. A schist of foliated mica, with interspersed and large irregular crystals of felspar; the quartz scarcely discernable.

E. An undulated coarse schist, consisting of large grains of felspar and of quartz closely packed, and connected by the smallest possible quantity of mica.

All schistose divisions present transitions from gneiss into quartz rock and micaceous schist.

Third Sub-Division.

Laminar—the ingredients forming distinct laminæ.

A. Quartz and felspar in alternating laminæ; belonging perhaps with D. to the 3d division.

B. Quartz, felspar and mica, simply alternating.

C. Quartz, felspar and hornblende disposed in the same manner.

D. Felspar and hornblende in alternating laminæ.

E. Quartz, mica and hornblende; the two latter in one lamina.

Second Division.

Of irregular composition; consisting of compact felspar united to some or all of the ordinary ingredients of gneiss.

A. Compact felspar and hornblende, occuring also as a variety of hornblende schist.

B. Compact felspar and quartz, in various proportions.

C. Compact felspar and chlorite.

D. Compact felspar, quartz and mica.

E. Compact felspar, quartz, and hornblende, or mica superadded.

F. Compact felspar superadded in various ways to any of the preceding varieties of gneiss, containing common felspar also.

Third Division.

Of irregular composition; being either deficient in the number of ingredients, or containing some substance not included in the definition of gneiss.

A. Quartz and felspar, laminar and granular at the same time; the foliated disposition resulting from the crystalline position of the felspar.

B. Hornblende and felspar, foliated and sometimes imperfectly schistose. Analogy and geological connection claim here a place for this rock, which is by some considered as primitive

greenstone, by others as hornblende schist, under which head it will be found.

C. Felspar and mica.

D. Felspar and clay slate.

E. Felspar and chlorite schist.

F. Felspar, quartz and chlorite schist.

G. Felspar, quartz and clay slate.

H. Felspar, quartz and talc.

I. A granular mixture of felspar and quartz in one lamina, and clay slate in another.

K. The same with chlorite schist instead of clay slate.

L. The same with greywacke schist.

M. Compact quartz with embedded grains of felspar in one lamina, and the same schists in the other.

N. Schistose felspar containing crystals of hornblende interspersed.

O. Actynolite occupying the place of hornblende.

P. Compact felspar, argillaceous schist, and any one or more of the other ingredients of gneiss.

SYNOPSIS OF MICACEOUS SCHIST.

First Division.

Consisting of mica and quartz.

First Sub-Division.

Simply laminar or foliated.

A. Formed of mica, continuously laminar, with the smallest possible addition of laminar quartz.

B. The preceding reversed as to ingredients.

C. The continuity of mica broken, and the quartz granular.

D. The mica greenish and more tender; approximating to chlorite schist.

E. The mica grey, but tender; approximating to talcose schist.

F. Similar to the preceding two; passing into argillite.

The preceding varieties are particularly liable to contortions.

Second Sub-Division.

Granularly laminar.

A. Granular quartz mixed uniformly with mica in a parallel position, producing the laminar fracture.

B. Granular quartz, occupying distinct laminæ, separable by the aggregation of scales of mica.

C. Granular quartz, divisible into laminæ, between which are interspersed scales of mica.

D. The same, with the scales of mica so disposed as to give the stone a fibrous appearance.

E. The mica imperfectly parallel and scaly, bent round the grains of quartz, giving a peculiar character to the rock in the transverse fracture.

Second Division.

Composed of three or more ingredients.

A. Many of the preceding varieties containing crystals or concretions of hornblende.

B. The same containing felspar, and passing into gneiss.

C. Containing chlorite or talc in addition, and passing into chlorite schist, or talcose schist.

D. Irregularly compounded with more than one of the above-named ingredients.

E. Containing carbonate of lime, with the usual ingredients, and giving it the appearance of gneiss.

Third Division.

Conglomerated.

Containing superadded fragments of granite, quartz rock, limestone and other substances.

SYNOPSIS OF ARGILLITE.

First Division.

Simple: of indurated shistose clay alone.

A. Straight fissile, or continuously laminar.

a. With a straight even fracture on the laminæ.

b. With a rough and undulated fracture.

The varieties form roof slate.

B. Imperfectly fissile, or massive slate.

a. Amorphous, sometimes breaking more easily in one direction than another.

b. Fibrous.

c. Massive, splitting with curved surfaces.

d. Black, imperfectly fissile, of dull earthy aspect.

e. Black, and so soft as to mark paper : black chalk or drawing slate Some varieties are fissile.

f. Spheroidal concretions embedded in the laminar varieties.

C. More compact, with a smooth splintery, or minutely granular and splintery fracture, translucent on the edges. Whet slate, or hone.

a. Compact, imperfectly fissile, the fragments translucent, and much resembling compact felspar —common hone.

b. Laminar or scaly ; straight or undulated, the fragments translucent—used as hone.

c. Granular, rough : less translucent.

D. So hard as to strike fire easily ; but the particles of quartz not visible.

This is the flinty slate or siliceous schist of some writers.

Second Division.

Compound: indurated schistose clay, with some other ingredient conspicuously mixed.

A. Simple argillite and mica.

a. The mica extremely thin and broad: passes into micaceous schist: the lustre silky or plumbaginous.

b. The scales of mica minute, intermixed irregularly, or in laminæ. The fine greywacke schist of some writers.

B. Simple argillite and talc; of a greasy feel, and silky lustre: passes into talcose schist.

C. Simple argillite intermixed with chlorite.

a. The chlorite invisibly minute, as if powdery, the fracture dull and earthy.

b, The chlorite foliated, or scaly, and the fracture glossy.

These varieties pass into chlorite schist.

D. Simple argillite with hornblende.

a. The hornblende in minute scaly crystals, or irregular grains, or flat plates.

b. The hornblende fibrous: fascicular: or else straight, or curved, and radiated.

Some varieties of *a.* pass into hornblende schist.

E. Argillite, A. div. 1st, intermixed with quartz.

a. An uniform mixture of sand and blue clay: imperfectly schistose, and resembling an argillaceous sandstone.

b. Argillite, massive, or laminar, mixed with quartz sand. The fine greywacke and greywacke schist of some writers.

c. Quartz gravel of various sizes, similarly intermixed: coarse greywackes.

F. Argillite, C. div. 1st, intermixed with quartz.

a. With very fine grains or powder of quartz. Not fissile: fracture sometimes rough and splintery, and often resembling the fine and grey varieties of sandstone.

b. With visible grains of quartz of different sizes, and resembling the coarser sandstones.

This also is termed greywacke.

G. Argillite, with embedded particles of calcareous spar.

H. Argillite, with embedded felspar, in crystals or fragments, having a porphyritic appearance.

Third Division.

Of argillite, with two or more ingredients.

A. Argillite with quartz sand, and mica.

a. Schistose.

b. Massive.

Occasionally termed greywacke. When the quartz is abundant, they pass into micaceous sandstone.

B. Argillite with quartz and felspar.

C Argillite, with quartz, felspar and mica.

These form other varieties of greywacke.

Fourth Division.

Containing fragments of the same or of other compound rocks : of a conglomerate structure.

A. Fragments of argillite re-united.

a. schistose ; slaty.

b. Imperfectly schistose ; or massive.

B. Fragments of quartz united by argillite.

a. With simple argillite.

b. With any of the compound varieties.

C. Fragments of quartz and of schistose slates, united by var. C. div. 1st—massive.

D. Quartz, felspar, and clay slate in minute fragments ; united, with or without any additional argillaceous cement.

E. Fragments of quartz and basalt, cemented by a mixture of clay slate and quartz sand.

F. Fragments of jasper and clay slate, with grains and fragments of felspar and of quartz, united by a siliceo-argillaceous base.

G. Fragments of micaceous schist and quartz, united by a mixture of schistose clay and sand, or of clay, sand, and mica.

H. The same, containing fragments of argillite.

This catalogue might be greatly extended; the most conspicuous only have been noticed. It comprises the coarse greywacke and greywacke schist mentioned as transition.

Fifth Division.

Argillaceous conglomerates.

All the varieties of the last division, with larger fragments, and consequently a coarse texture.

SYNOPSIS OF SERPENTINE.

First Division.

Opake.

A. Common serpentine.

a. With an earthy uniform fracture.

b. With a splintery fracture, passing to the conchoidal.

c. The same, passing to the granular.

d. With a granular fracture.

B. Softer, and becoming gradually sectile: the potstone of some mineralogists.

C. Passing to indurated talc; the potstone of

others, and mentioned under the head of talcose schist.

The usual colour of these varieties are green, black, brown, red, and purple of all tints; yellow, pink, lilac, and pale grey are more rare. The variations and admixtures of these in clouds, spots, and veins are infinite.

Second Division.

Translucent.

A. Noble Serpentine.

a. Foliated and splintery.

b. Conchoidalor, splintery conchoidal.

SYNOPSIS OF PRIMARY LIMESTONE.

First Division.

Simple.

A. Crystalline.

a. Very large grained, with lamellæ straight or curved.

b. Large grained, the crystals appearing to have compressed each other, as in coccolite.

c. Middle sized grain—Parian marble &c.

d. Finely granular, saccharine, and firm or loose—the marble of Carrara, &c.

e. Finely granular and compacted, becoming splintery.

f. The crystals so placed as to exhibit an im-

perfect shistose structure; and to appear as if it contained mica.

B. Compact.

a. splintery; with a rough granular fracture.

b. Flat splintery; smooth.

c. Splintery and conchoidal.

Second Division.

Compound: of two ingredients.

A. Limestone, with mica interspersed.

a. Foilated, irregular, large granular, resembling granitic gneiss.

b. Straight laminar, resembling micaceous schists.

B. Interlaminated with argillaceous schist.

C. With hornblende interspersed.

D. With sahlite or augit of various colors interspersed.

E. With talc interspersed.

F. With noble serpentine or steatite so intimately diffused as to give a general color to the mass.

G. With garnets diffused, sometimes crystallised.

H. With quartz, in grains or so very minute as not to be visible.

I. With felspar.

K. Impregnated with bitumen.

L. With tremolite minutely intermixed.

M. With actynolite, in the same manner.

Third Division.

Compound: of three ingredients.

A. Limestone with noble serpentine and mica.

B. The same with sahlite,

C. With hornblende and augit.

Fourth Division.

Compound: consisting of any of the preceding varieties, with fragments of other rocks, or of other limestones.

Conglomerates.

A. With limestone fragments alone, united in various ways.

a. The fragments imbedded in a general continuous calcareous base.

b. The fragments agglutinated with little or no proper base, and of various sizes.

B. Fragments of quartz imbedded in limestone.

C. Fragments of argillite imbedded in do.

D. Fragments of several primary rocks, with or without fragments of limestone also, imbedded in a calcareous base.

Some of these are noticedagain in the Synopsis of Conglomerates.

SYNOPSIS OF QUARTZ ROCK.

First Division.

Simple: of quartz alone.

A. Pure quartz, similar to that found in veins.

a. Hyaline.

b. Opake.

B. Pure quartz, compact, laminar: finely fissile, almost scaly; sometimes laminar and striated.

C. Granular splintery; sometimes passing into the compact.

D. Granular: with large grains or concretions.

a. Compact, crystalline, transparent or opaque.

b. Gravelly, with distinct condensed grains.

E. Arenaceous, or finely granular.

a. Condensed saccharine, passing into var. C.

b. Loose, arenaceous, resembling secondary sandstones.

Second Division.

Compound: of two ingredients.

Of quartz and felspar.

A. The quartz compact, opaque or hyaline, with imbedded particles of felspar dispersed irregularly.

B. The same, with the felspar assuming a laminar direction: and predominating more in one lamina than in another.

C. An uniform rock, more or less laminar, with a fracture between granular and splintery.

D. The quartz and felspar both in distinct grains and in various proportions.

a. Highly compacted, and cemented by silex, or quartz.

b. Gravelly, or sandy, sometimes loose.

Of quartz and mica.

A. Compact quartz, with scales of mica interspersed.

a. The quartz opaque.

b. ————hyaline. (aventurine)

B. Laminar: occasioned by the position of the mica.

a. The mica in distinct scales, dispersed, but parallel.

b.. The mica forming distinct laminæ.

This latter passes into mica slate.

Of quartz and blue schistose clay.

A. The two substances in alternate laminæ.

B. Quartz, arenaceous, and minutely interlaminated with clay, similar to the sandstone accompanying coal.

C. Quartz sand and blue clay intimately mixed.

This last passes into fine grey wacke schist.

Third Division.

Conglomerate: with more than two ingredients.

A. Quartz sand alone, or sand and gravel of quartz and felspar, with imbedded pebbles or fragments of quartz.

B. The same, with fragments of argillite.

C. The same, with fragments of mica slate, or with both.

These pass into coarse grey wacke.

SYNOPSIS OF CHLORITE SCHIST.

First Division.

Simple: of Chlorite only.

A. Foliated Chlorite; plain or undulated: with minute, or with large undulations.

Second Division.

Compound: of two ingredients.

Foliated or simple laminar and alternating.

A. Foliated chlorite with laminar quartz.

B. ——————————granular quartz.

C. ——————————laminar felspar,

D. ——————————grains or imperfect crystals of felspar disposed in a laminar manner.

Granularly laminar: mixed.

A. Scaly or imperfectly foliated chlorite with quartz sand.

a. Large grained, with a rough granular fracture.

b. Small grained, with a homogeneous aspect, and often scarcely fissile.

c. The preceding varieties, passing into grey wacke schist, and into argillite.

B. Scaly chlorite with large grains of quartz. Similar in structure and appearance to mica slate E. 1st div: 2d subdiv.

C. Scaly chlorite, with large imperfect crystals of felspar: similar in structure to the preceding, and resembling granitic-gneiss.

D. Scaly chlorite, highly compacted, with minute grains of felspar interspersed: difficulty fissile: occasionally granular, and fibrous.

E. Scaly chlorite with hornblende, intermixed or imbedded, and passing into hornblende schist.

F. Scaly chlorite intermixed with actynolite: very compact, sometimes fibrous, difficulty fissile.

G Scaly chlorite with mica: passing into mica slate.

Third Division.

Compound: with more than two ingredients.

Laminar; alternating.

A. Foliated chlorite, felspar and quartz.

This occurs in the series of gneiss, and is there introduced.

Granularly laminar; mixed.

A. Scaly chlorite, quartz, and felspar.

B. ———————— felspar and mica.

C. ———————— hornblende and mica.

D. ———————— hornblende, quartz, and green compact felspar.

SYNOPSIS OF TALCOSE SCHIST.

First Division.

Simple: of one ingredient.

A. Schistose talc.

a. Scaly and foliated.

b. Scaly and semigranular.

c. Minutely scaly-granular and indurated: potstone of some mineralogists.

This variety passes into serpentine, and has there been mentioned.

Second Division.

Compound: of two ingredients.

A. Talc, and quartz: foliated; the quartz variously disposed, and the rock resembling mica schist, into which it passes.

B. Talc, and foliated or scaly chlorite; passing into chlorite schist,

C. Talc and felspar.

D. Talc and argillite: passing into argillite, under which head it has been mentioned.

E. Talc and serpentine: passing into serpentine.

Third Division.

Compound: of three ingredients.

A. Talc, quartz, and felspar.

B. Talc, quartz, and mica.

SYNOPSIS OF HORNBLENDE ROCKS.

First Division.

Simple: of hornblende alone.

A. Very compact, with a smooth and dull fracture: the particles being scarcely discernable.

B. Granular, from small irregular aggregated crystals: of different degrees of fineness.

C. Scaly, from an aggregation of flat crystals.

D. Flat, continuously laminar.

E. Fibrous.

a Simply fibrous, and with snort fibres.

b. Fibrous radiated.

c. Very fine fibrous and silky.

F. The texture so fine that it loses its character, and passes into argillite.

The above are sometimes imperfectly, or not at all fissile, and then form what is usually named hornblende rock.

Second Division.

Compound: of two ingredients.

A. A laminar alternation of hornblende and felspar

a. Continuous platy and schistose, easily fissile.

b. The same, but not at all fissile.

c. Granularly laminar, and imperfectly schistose.

B. The hornblende scaly or fibrous, and the felspar arenaceous; not in distinct laminæ.

C. A granular uniform mixture of the same ingredients.

a. Scaly, imperfectly fissile.

b. Uniformly arenaceous and mixed: fissile.

c. Mottled, the hornblende being condensed in patches and spots.

d. Dull: the ingredients being minutely intermixed and compacted.

e. A very compact, distinct intermixture of the two ingredients. Not schistose, nor distinguishable from the greenstone of the superincumbent or overlying rocks.

The modifiations of aspect and color are many, arising from the size, and quantity, and color of the grains. These varieties are the primitive greenstone of many.

D. The felspar in excess, the mixture granular. Entirely different from any other hornblende rock.

E. A minute mixture of hornblende and dark compact felspar; the two ingredients scarcely distinguishable.

F. Common hornblende schist with interspersed particles and filamentous veins of bright green compact felspar.

The two latter varieties are very remarkable.

G. Hornblende with mica; the former in excess, and the rock fissile. Mixtures of mica schist and hornblende differ from this variety in containing quartz, and are enumerated with mica schist.

H. Hornblende and chlorite.

This is mentioned under the head of chlorite schist.

I. Hornblende and actynolite: passing into actynolite schist. The hornblende is black, and scaly or granular; the actynolite green and fibrous.

K. Hornblende and indurated talc: passing into serpentine, and mentioned under that head.

Third Division.

Compound: of three or more ingredients.

A. Hornblende, mica, and felspar.

B. Hornblende, felspar and quartz.

C. Hornblende, actynolite and mica.

D. Hornblende, chlorite and felspar.

E. Different quaternary mixtures of these ingredients.

Some of these varieties are also found under the head of gneiss, and some other rocks. The size, proportion, and col.r of the several constituents vary and communicate many different aspects to these rocks.

SYNOPSIS OF ACTYNOLITE SHIST.

First Division.

Simple: of one ingredient.

A. Actynolite under various appearances.

a. Formed of distinct interlaced crystals of various sizes.

b. Formed of a confused aggregate of small crystals: sometimes acicular.

c. The same passing into a granular texture.

d. Flat foliated.

e. Fibrous: the fibres straight or undulated.

This division exhibits some shade of green, from dark bottle green to sea green: sometimes, rarely, white.

Second Dvision.

Compound: of two ingredients.

A. Actynolite and felspar.

B. ————————hornblende.

C. Actynolite and mica.

D. ——————talc.

E. ——————chlorite.

The last is mentioned also under chlorite schist.

Third Division.

Compound: of three or more ingredients.

A. Actynolite, hornblende, and mica.

B. Actynolite, hornblede, felspar, and mica.

Porphyry, syenite, greenstone, and greywacke are included in the synopsis of the superincumbent or overlying rocks, and mentioned in others.

SYNOPSIS OF THE OLD RED SAND STONE.

First Division.

Simple: of quartz alone.

A. Sandstone of various degrees of hardness.

a. Fine, arenaceous.

b. Gravelly.

c. Compact, splintery, scarcely arenaceous.

The last variety only to be distinguished from quartz rock by its position. The members of this division are rare.

Second Division.

Compound: of two or more ingredients.

A. Quartz sand, mixed with clay. Argillaceous sandstone.

a. Gravelly.

b. Fine arenaceous.

c. Very fine, the particles of quartz invisible. This last passes into shale and argillaceous iron stone.

B. Quartz sand, mixed with sand or particles of felspar.

a Gravelly.

b. Arenaceous.

C. Quartz sand with carbonate of lime: calcareous; sandstone.

a. Gravelly.

b. Arenaceous: generally white.

D. Quartz sand with carbonate of lime and clay: argillo-calcareous sandstone.

a. Gravelly.

b. Arenaceous.

These derive their color from the clay: when the quartz is fine and in small quantity, they pass into calcareous shale or marle slate.

E. Quartz sand with mica, and, sometimes, clay: of different degrees of fineness.

a. The mica, scattered throughout: massive.

b. The mica disposed in a parallel manner, often in separate laminæ: schistose, and more or less fissile. Schistose sandstone.

F. Quartz sand with indurated or schistose clay.

This comes under the head of argillite (gray-wack) where it is also mentioned.

G. Quartz sand, with sand from the disintegration of trap rocks.

Third Division.

Containing fragments of the previous rocks: of a conglomerate structure. Red sand stone conglomerate, or breccia.

A. The basis consisting of either of the preceding fine varieties, except F. and G. 2d Div: and containing fragments of quartz only..

B. Similar basis, with fragments of one, or of all the preceding rocks, except argillite, with quartz also.

C. The same, including F. 2d Div. with fragments of argillite.

D. The base G. 2d Div. with fragments of the traps.

E. The same basis as var. A. containing fragments of sandstone, with or without fragments of preceding rocks.

SYNOPSIS OF COAL.

Simple: Carbon nearly pure.

A. Burning with difficulty and without flame: anthracite, when perfect.

This modification of carbon contains so little hydrogen as to afford neither naptha nor petroleum on distillation : of course it yields neither flame nor smoke.

a. Massive; with a conchoidal shining fracture; of an aspect nearly metallic : is found among primary rocks : passes into plumbago.

b. Friable, pulverulent, or scaly. Rare.

c. Laminar : blind coal, stone coal, Kilkenny coal.

This and the preceding varieties are found in primary strata; and sometimes in the secondary. The last passes into common coal.

d. Columnar, or prismatic. Found in the vicinity of trap rocks, and passes into plumbago.

Second Division.

Compound : Carbon and bitumen.

A. Flaming, and burning easily, with smoke. Common coal; occurs massive and slaty united. Several varieties, according to the quantity of bitumen it yields. They pass into bituminous shale and are invariable secondary.

B. Very inflammable : leaving little coak; massive or imperfectly laminar : large conchoidal fracture : more or less bright, sometimes dull. Cannel coal, occurs with the secondary coal—and is sometimes cut, like jet.

C. Coak, Ashes, and smut: rare and partial modifications, occurring with the trap rocks.

Third Division.

Lignite: retaining marks of vegetable origin.

A. Jet, or pitch coal, black amber; hard and compact: pitchy lustre, takes a good polish; occasionally shows the ligneous fibres. Used as fuel. In Aude, in France, 1200 persons are engaged in making ornaments of it.

B. Fibrous brown coal; bituminized wood: Bovey coal. The ligneous fibre very distinct; burns with a clear flame.

The suturbrand of Iceland belongs to this variety.

C. Earth coal, or earthy brown coal; pulverulent, retaining the texture of wood, though compact: burns easily. Known also as Colonge earth or umber.

D. Moor coal; friable: nearly the same as brown coal, into which it passes. It breaks on exposure to air.

All the preceding varieties occur in the newer formations: mostly in the tertiary and alluvial, occupying extensive tracts, in strata of various thicknesses. Not much used as fuel.

E. Basaltic coal: basaltic wood retaining the texture of wood and passing into true coal. Found in trap rocks.

SYNOPSIS OF PEAT.

Although peat does not properly come under the head of rocks, I do not see a more appropriate place for its Synopsis than the present. It has been spoken of before, and the following are the varieties.

A. Loose or powdery, and often intermixed with clay or sand: mountain and heath peat.

B. Spongy, imperfect, and containing a large proportion of the roots and fragments of undecomposed vegetables.

C. Compact, but still retaining numerous fragments of vegetables, and passing into the former. The most ordinary variety used for fuel.

D. Highly compact, with a total loss of vegetable texture. Heavier than the last, and burns nearly like coal, with a considerable flame. More rare than the former.

The varieties B. and C. are always in the same deposit, and frequently D, the spongy kind being above and becoming more compact below, exhibiting the progress of vegetable decomposition or the perfection of peat. When wet in their natural

position all varieties are soft, and harden by drying.

E. Compact generally flaky when dry, and containing fragments, roots, and trunks of trees. Forest peat.

F. When wet, a mixture of water and fine powder of peat: on drying, very compact. Transported peat; forming fluid bogs.

As long as vegetaton is kept up, the peat is renewed after removal: but the process ceases when the vegetating surface is removed, unless it is renewed by nature or artificial means; except in transported peat.

SYNOPSIS OF SHALE.

First Division.

Simple.

A. Common Shale.

a. Hard, and often not distinguishable from argillite and graywack: occurs mostly with old red stone.

b. Fragile, and less laminar than the preceding.

c. Tender and Scaly.

d. Passing into clay.

e. Granular concretionary.

f. Spheroidal concretionary.

The colors of these are grey; when they change into red or yellowish, it passes into

B Ferriferous shale.

a. Laminar, simple, pink, red, purple, brown, obscure blue, yellow, or variously mottled.

b. Laminar and short columnar: surfaces singularly channelled on the margin. Columnar ironstone.

c. Containing red oxide of iron in excess, and passing into common iron stone.

C. Adhesive slate.

D. Polishing slate: lighter than water.

Second Division.

Compound.

A. Argillo-bituminous.

a. Slightly impregnated with inflammable matter.

b. So slightly impregnated with bitumen as to be combustible. Black and brown. Kimmeridge coal, accompanies true coal.

B. Argillo-calcarcous; containing so much carbonate of lime as to effervesce with acids.

C. Argillo-micaceous; containing a considerable portion of mica.

D. Arenaceo-micaceous; in which sand enter in quantities.

E. Quartzose: passing into the flagging sandstone.

F. With rounded fragments of trap and other rocks imbedded.

G. Alum slate—aluminous schist: affording an aluminous saline efflorescence on exposure to air, particularly if accompanied by heat and moisture.

SYNOPSIS OF GYPSUM.

A. Granular.

a. Tender.

b. Compact—alabaster of artists.

B. Fibrous: sometimes dull, often highly splendent.

C. Platy, on the large scale, or approaching to large granular.

SYNOPIS OF SECONDARY LIMESTONE.

First Division.

Simple, or nearly so; formed of carbonate of lime with little or no intermixture of other earths. Effervesces readily and burns to lime which is easily slackened.

A. Crystaline: more or less perfect,

a. Granular.

b. Granular splintery.

B. Compact, with a smooth fracture, more or less glossy.

a. Flat, splintery.

b. Splintery, and small conchoidal.

C. Thin laminar, scarcely schistose.

D. Fibrous, or prismatic.

a. Fibrous more or less minute, the fibres simple, parallel, and coalescing, sometimes slightly undulated. The lustre occasionally silky, and the color white; forming satin spar.

b. Fibrous, the fibres ramifying: coalescing, and with a pseudo-organic structure.

c. Prismatic, parallel or radiating: the prisms separable, more or less easily: sometimes striated, and with an obscure appearance of joints: madreporite.

E. Concretionary spheroidal. *Peastone, roestone, and oolite.

a. With large spherules, sometimes compressing each other.

b. With moderate sized spherules, roestone.

c. With minute spherules, varying much in size, and sometimes distinct: oolites.

d. The spherules intermixed with irregular fragments: the Purbeck stone.

F. Fragile, or easily sectile.

a. With a smooth somewhat glossy fracture: indurated chalk.

b. With an earthy fracture; compact, but soft: common chalk.

c. Containing clay: grey chalk.

d. Earthy, incompact: chalk marle.

All these varieties become occasionally impure, and pass into those of the next division. The most usual colors are white, pale grey, dove, dark grey; red of different hues, greyish brown, dark brown, black.

Second Division.

Compound: containing a considerable proportion of other substances. The nature of the mixture ascertained by chemical analysis, but afterwards recognized by external characters.

A. Calcareous carbonat, with magnesia, chiefly. Magnesian limestone.

a. Massive.

b. Laminar, and flexible when moist.

B. Calcareous carbonat, with a large proportion of clay intermixed, and some silica. Lias limestone.

a. Massive: sometimes in laminæ divided so minutely by clay or shale, as to seem schistose.

Some of them form a slag by great heat: will not burn so as to slack: some varieties, when sudden-

ly wetted, harden like tarras cement, and may be used for lythographic purposes.

b. Concretionary small spheroidal; botryoidal.

c. Concretionary: large spheroidal, generally oblate, and sometimes attached in pairs by a cylindrical bar.

C. Calcareous carbonat with a considerable proportion of oxide or rust of iron, as well as of clay and silica. Spheroidal, flattened. Often divided internally into prisms by calcareous spar; Septaria: this produces water cement like some of the above.

D. Calcareous carbonat with considerable proportions of clay, silica, and oxides of iron. Occurs with the old red sand stone.

a. Imperfectly granular, shining.

b. Earthy.

c. Smooth, the fracture splintery, or approaching the conchoidal. This becomes so surcharged with other earths as to pass into calcareous shale, or marle slate.

E. Carbonate of lime, more or less pure, and intermixed with bitumen. Bituminous limestone.

F. Carbonate of lime, intermixed with a large proportion of silica chiefly. It effervesces with great difficulty, unless in powder: forms a slag in the fire: passes into calcareous sandstone. When

near to trap is often highly indurated, assuming the character of chert.

Third Division.

Compound: containing some visible ingredient intermixed.

A Limestone containing mica.

B. Limestone containing mica and sand.

These occur with mica or micaceo-arenaceous shale.

Fourth Division.

Containing fragments of limestone, or of quartz, or of different compound rocks. Conglomerated.

A. Containing fragments of previous limestone.

B. Containing fragments or pebbles of quartz.

C. Containing chert or agate in fragments.

D. Containing fragments of argillite.

There are other divisions of limestone, often well marked; sometimes arising from actual change ofcharacter, from the presence of fossil contents, or from color: mostly however these names are local or geographical: the latter is perhaps the safest, as it can always be referred to and known.

SYNOPSIS OF SAND STONES.—(SUPERIOR.)

The term superior sandstones is here used

as the Divisions of these sandstones are different from, and above the old red sandstone.

First Division.

Simple: of quartz alone.

A. An aggregate of grains of quartz, more or less condensed, and varying in hardness.

a. Of a large grain; gravelly.

b. Fine, arenaceous.

The brillancy of these varieties, which are almost necessarily white, varies according to the quality of the quartz from which they are formed. When highly indurated, their position alone distinguishes them from quartz rock. In the vicinity of trap, they are said to be indurated occasionally to the state of common quartz.

Second Division.

Compound: of two or more ingredients.

A. Quartz-sand and carbonate of lime.

a. Large grained, gravelly.

b. Fine, arenaceous.

These are generally white.

B. Quartz sand with clay.

Subdivisions *a.* and *b.* as the preceding.

The colors vary: white, ocre yellow of different hues, or red, or grey, or greenish, or black:

occasionally mottled or striped. The red varieties and sometimes even the white and grey are distinguishable from the old red sand stone, only by their geological position, and this it is sometimes impossible to ascertain.

C. Quartz sand with schistose clay.

The clay is more or less interlaminated and the rock passes into shale.

D. Quartz sand with clay and carbonate of lime.

Subdivisions *a.* and *b.* similar to var. A. and B.

E. Argillaceous or calcareo-argillaceous sandstone mixed with bitumen.

This sometimes passes into bituminous shale.

F. Quartz sand with clay and mica, or with clay, carbonate of lime, mica and red oxide of iron.

The red marle, or new red sand stone of England, is of this kind.

G. Quartz sand with carbonate of lime, mica and green earth, called in England, Kentish rag.

H. Sandstone of various qualities containing a large portion of rust of iron, which often forms the cement of the other ingredients: ferruginous sandstone.

The varieties of this division, like those of the preceding, when in contact with trap, are said to pass into jasper or chert. They sometimes contain pyrites, carbonate of copper, oxide of cobalt, and oxydulous iron.

Third Division.

Conglomerates.

A. Sandstone containing fragments of quartz.

B. ———————— nodules of trap.

C. ———————— fragments of previous sandstones.

D. Sandstone containing fragments of schistose clay or shale, or of limestone, or of both.

E. Sandstone containing flints. English puddingstone. This is occasionally of a loose arenaceous texture; or is highly indurated. Doubtful if it is not alluvial.

SYNOPSIS OF CLAY

The clay and the marle and sand mentioned in the following synopsis belong mostly to the Tertiary formations.

A. Ferruginous clay: scarcely ever plastic, red or yellow.

B. Fuller's earth: dull green or grey: semitransparent, and crumbling when in water. Occurs in the upper sandstones, in the limestones and new red marle.

C. Schistose clay: white or grey: scarcely ever plastic, until after exposure to air, when it crumbles. Pipe clay, often above the chalk.

D. Indurated, generally in irregular nodules; very refractory in the fire. Stourbridge clay.

E. Plastic clay, potter's clay, of various colours and properties. Very similar to var. C. New Jersey clay.

F. Blue clay: London clay: plastic in various degrees.

There are other varieties of clays, passing into different substances—besides lithomarge, tripoli, &c.

SYNOPSIS OF MARLE.

A. Simple, or earthy: consisting principally of calcareous matter.

a. Massive, more or less compact.

b. Schistose—marle slate.

c. Powdery, or imperfectly plastic, with few or no fragments of shells: often much mixed with sand and clay.

d. A congeries of shells and fragments of shells, more or less pure Shell-marle of agriculturalists. New Jersey, &c. Some of the varieties, *a* & *b.* become plastic on exposure to air.

B. Bituminous marle: more or less distinctly schistose. There is some obscurity in this substance, since it is known to contain fish, and it is

said to be found in different parts of Europe, in connection with primary lime-stone.

SYNOPSIS OF SAND.

A. Quartz alone.

B. ——— and clay.

C. ——— and limestone, or limestone and clay.

D. ——— and mica.

E. ——— and highly ferruginous clay, or ochre, with other less important substances: ferruginous or iron sand.

F. Quartz, limestone, mica, and green earth. Green sand.

SYNOPSIS OF ALLUVIA.

First Division.

Loose.

A. Single stones, more or less accumulated in particular places, generally bearing marks of waste in a greater or less degree, and commonly consisting of the older rocks. Granite boulders are the most conspicuous and frequent: but there are boulders of other rocks: single in the interior of countries, and forming heaps on sea shores.

B. Stones of various sizes mixed with sand or clay, or both.

a. The produce of one rock: alluvia formed in situ.

b. Pebbles of flint with sand and clay. It is questionable whether the pebbles were originally rounded, or if they have been worn by the action of water.

c. Rounded fragments of various rocks, intermixed with clay or sand. Alluvia of rivers—and Diluvian alluvia.

d. Fragments slightly rounded, or angular, with clay and sand. Alluvia of descent.

C. Of fine materials, consisting of sand and clay, more or less compacted.

a. Clay.

This embraces many varieties, containing different proportions of silex and alumine, and occasionally magnesia and lime. The decomposition of granite furnishes an excellent porcelain clay:—and gneiss yields by the same process a white clay of some value.

b. Clay with a large proportion of sand: loam of agriculturalists.

c. Compact sand, always with a mixture of fine clay sufficient to consolidate it: found in the alluvia of rivers and lakes, and on the sea shore.

d. Clay containing inflammable or carbonaceous matter arising from the decomposition of ani-

mals and vegetables: Mud. Found in estuaries, and in the deposits of sluggish streams.

D. Of fine materials, and loose or incompact.

a. Quartz sand.

On sea shores, and also removed by winds, so as to form sand hills and other similar inland deposits, which are consolidated by the growth of vegetables. Long Island, New Jersey, and Virginia sand hills.

b. Of calcareous sand; commonly from the decomposition of sea shells, and found under similar circumstances.

E. Sand of various constitution, found in partial deposits in different places, and commonly, if not always, arising from the decomposition of rocks.

a. Quartz and argillite.

b. ——— ——— felspar.

c. ———————— the sand of trap rocks.

d. Mica: or mica with clay, or felspar, or quartz or hornblende, or all of these. From granite and gneiss.

F. mixtures of various kinds, forming the soil of agriculturalists. Some of these are transported materials, others are produced by the decomposition of rocks in situ. Those arising from the decomposition in situ of the trap rocks, of argillace-

ous limestone and of argillite, are the most fertile and valuable.

G. Vegetable soil, or mould, consisting of a mixture of any of the preceding with a hydro-carbonaceous compound, analogous to peat, resulting from the decomposition of vegetables. This substance confers fertility on the compound in proportion to its quantity, other circumstances being equal.

Second Division.

Solid.

Simple.

A. Compacted sand of quartz, or recent sandstones: sometimes found in the river alluvia: tender.

B. Compacted shell sand: recent oolite.

Frequent in the Bahama Islands and similar situations. The grains often perfectly round, and serving to elucidate the origin of the older limestones of this nature.

C. Compact limestone, deposited from the waters of existing rivers and lakes in large masses.

The travertino of Rome, and the stalagmitic rocks, similar to that of Gibraltar come under this head.

Compound.

A. Substances of various kinds and sizes cemented by carbonate of lime.

a. Quartz sand cemented in this manner.

On sea shores and in river alluvia.

b. Fragments of many kinds cemented in the same way into a solid mass.

On sea shores.

B. Various substances cemented by rust of iron.

a. Quartz, sand, and gravel: recent ferruginous sand stone. Similar to the iron sand in its most solid state.

b. Flint, gravel, clay, and sand, cemented in the same way.

Some trap rocks seem to undergo a similar process after disintegration; forming a recent tufa.

SYNOPSIS OF THE OVERLYING OR SUPERINCUMBENT ROCKS.

First Division.

Simple: or apparently so.

A. Wacke, of the German school. Resembles indurated clay, with an even and smooth earthy, or an uneven somewhat granular fracture, and a shining streak.

a. Compact.

b. Cellular: but generally in that case, partly

amygdaloidal, and appertaining to another division.

B. Indurated clay: more or less hard, with an earthy and dull fracture.

a. compact.

This is different from the ferruginous clays found often with the trap rocks, which pass into jasper.

b. Cellular.

Like var, A. *b.* it is rarely cellular in large masses, without also containing amygdaloidal nodules, when it passes to another division. The colors of this variety are usually ash, or grey, of different hues, or modifications of red, or brown, or purplish black.

C. Claystone. The fracture is dull and earthy, and may be smooth and even, or rough and somewhat granular, or imperfectly splintery. or conchoidal. It differs from the preceding substances in hardness; but there are no definite distinctions in this case. Its structure is never schistose, and this, independently of its geological differences, distinguishes it from argillite.

a. Massive, irregular.

b. Prismatic, or columnar.

c. Laminar.

d. Cellular.

The laminar structure is seldom seen, except on the surface, and after exposure to weather. It is

sometimes combined with the prismatic structure, but cannot easily be confounded with the schistose argillite. The colors of claystone are pale greyish, or muddy white, or ochre yellow, of various degrees, or flesh color, or purplish, or different tints of grey, from smoke color to dark lead grey, nearly black.

This variety is most common in mountain masses; it is found but rarely in veins.

D. Indurated claystone. Harder than the former, and distinguished by the superior lustre and acuteness of the fractures, which are also granular, splintery, or conchoidal It is separated, not so much on account of its mineralogical differences, as from its geological importance. It forms the most extensive and the most common rock of this class in the north of Great Britain.

a. Massive, irregular.

b. Prismatic, or columnar.

c. Laminar, under the same circumstances as C. *c.*

The dark varieties, particularly when prismatic or in veins, are often called basalt, and may be considered as forming varieties under this popular and indefinite term. It is found in veins and in mountain masses; frequently in the former, and it thus occurs sometimes with the seemingly ancient

porphyries that traverse granite. The colors are the same as those of the preceeding variety. Some specimens of brilliant colors are called jasper, to which they approximate.

E. Clinkstone This is still harder than the preceeding variety, and is not scratched by the knife. The fracture too is more perfectly splintery and conchoidal: occasionally somewhat granular; the lustre more considerable, and the fragments slightly translucent on the edges. It is sonorous, but not more so than many other members of the trap family. Its mineral characters have been mentioned.

a. Massive.

b. Columnar, or prismatic.

c. Laminar

The dark varieties of *b.* have, like the former, been enumerated among the basalts The same remarks as in the two preceeding cases, may be made on var. *c.*

The colors and geological positions are similar also. The surface, when weathered, becomes arenaceous, and has been confounded with sandstone.

The substances C. D. and E. pass insensibly into each other, as do other rocks.

F. Compact felspar, including hornstone. Its

superior hardness, compactness and lustre distinguish it from the preceeding, to which it is allied. The edges are more decidedly translucent.

a. Imperfectly laminar.

b. Massive, with a smooth, splintery, and conchoidal fracture.

c. Crystalline-granular.

The var. *a.* and *b.* occur simple, in veins, but are frequently slightly porphyritic in some places: never as mountain masses.

Var. *c.* assumes different aspects according to its fineness. The colors are usually those of the preceding varieties: but sometimes, grains of two colors (as white and dark lead-blue, or greyish green and blackish green) occur, and it has then been mistaken for greenstone.

Fawn and cinnamon colors are seen in var. *a.* *b.* also brick red, muddy white, and of every tint from grey to black From clinkstone to compact felspar, there seems to be a gradation similar to that between C. D. E. Simple compact felspar passes very generally into porphyry. The varieties C. D E F. in the same way, become porphyritic or amygdaloidal.

The preceding rocks, particularly C. D. E. lose their natural characters for some depth beneath the surface; retaining their solidity, but acquiring

an arenaceous aspect, and changing color, so that the dark indurated claystone or clinkstone assumes the appearance of indurated clay, var. B.

G. Hornblende compacted into a solid mass, and apparently consisting of minute crystalline particles. The fracture is coarse grained, and is, further, uneven, splintery, or conchoidal. It varies in lustre—sometimes glistening. It is one variety of basalt: the only basalt of some authors.

Basalt by analysis, yields soda, but hornblende does not.

a. Massive, irregular.

b. Laminar.

c. Columnar or prismatic.

This basalt is found in veins and masses—in the former, laminar. The var. *b.* *c.* are sometimes joined, as in claystones, the laminæ being either parallel or at right angles to the axis of the prism.

Basaltic columns are sometimes jointed, as before mentioned: but that structure is not confined to basalt; nor is it characteristic.

Second Division.

Compound: formed of two substances.

Granitiform mixtures.

A. Hornblende and compact felspar.

a. In nearly equal proportions, or the horn-

blende predominant, and the two minerals distinctly visible. Greenstone.

It occurs in veins and in mountain masses; and like some of the preceding is columnar, as well as laminar. The hornblende is black or dark green and sometimes crystallised. The felspar is white, yellowish, red of different hues, pale green, or grey from light to nearly black. The relative proportion, and size, and color, of the particles give a variety of aspects. Rocks not distinguishable from the dark varieties occur, togetner with granite, as already mentioned.

The felspar is sometimes accumulated in spots, in the mixture, presenting a porphyritic aspect, and forming pseudo-porphyries.

When the felspar is red, the compound is often mistaken for granite.

b. Compact felspar predominant. Syenite.

It occurs mostly in mountain masses, rarely in veins. It is occasionally partially laminar, and columnar. Like other members of this family, it does not preserve the same appearance for any considerable extent—varying with the proportions of the constituents It is sometimes even simple, to the exclusion of hornblende. This is one of the Syenites, of this family.

c. The mixture imperceptible, or nearly so, to the naked eye. In this variety the hornblende is in equal or greater proportion than the felspar, which is usually dark; hence the compound is dark grey, or greenish black or nearly black. This is sometimes called basalt: presenting the same appearances as some varieties of D. E. and G. First division—and like them columnar as well as laminar occasionally.

B. Hornblende and common felspar.

a. In nearly equal proportions.

The rocks of this variety are generally called greenstone, although differing in appearance from the varieties of A. into which, however, they pass. Some mineralogists call them syenites; they do pass into them by an increase of felspar. When the felspar is red, they resemble some varieties of granite.

b. The felspar predominant.

This too forms one of the prevailing varieties of Syenite: and is found under precisely the same circumstances as var A. *b*. Its aspects is more decidedly granitic than the variety containing compact felspar. When the felspar is dark gray, as is sometimes the case, the compound has been improperly termed greenstone.

C. Compact felspar and quartz.

This occurs occasionally in conjuction with syenite and the simple rocks. Quartz is found in the same way connected with indurated clay andclinkstone.

D. Common felspar and quartz.

This compound occurs among syenites and analogous rocks.

E. Hornblende and glassy felspar.

This is rare, and occupies but small spaces.

F. Augit and compact felspar.

a. The augit in equal or superior proportion to the felspar, distinctly intermixed. Augit rock.

This occurs in veins and extensive masses; and is occasionally laminar and columnar. Its appearance varies according to the relative proportion, size, and color of the augit.

b. In such a state of intermixture that the parts are nearly or altogether invisible.

The colors of this compound are black, or with some shade of green. It has been confounded with some basalts—having the same fracture general appearance.

c. The felspar in excess, and both minerals distinct.

This compound resembles the analogous varieties of syenite, into which hornblende enters. Like the common varieties of Syenite, it presents various aspects.

G. Augit with glassy felspar.

Perhaps augit forms other compounds: it occasionally is an ingredient in a ternary compound with hornblende.

H. Hyperstene with compact felspar.

I. ———————— common felspar.

K. ———————— glassy felspar, and sometimes with the addition of common felspar. Hyperstene rock.

These three varieties have been insisted on by Dr. Macculloch. They occur in beds, in mountain masses: never in veins, nor columnar. Occasionally they exfoliate like granite, and sometimes possess a foliated structure like gneiss, from the parallel position of the hyperstene. The structure is generally granitic, and varies according to the size and proportion of the ingredients. Sometimes it resembles granite, and at others greenstone: and with an addition of imbedded crystals of felspar, it occasionally resembles graphic granite. When very fine, it approaches to basalt.

Compound: of two substances; one of which is more or less distinctly crystallised and embedded in a simple base of the other. Includes some porphyries.

A. Claystone, common or indurated, with imbedded scales of mica, sometimes regularly crystallised.

This is found in veins and in masses; but is rare.

B. Grains, or imperfect crystals of quartz imbedded in a simple base.

a. Base of claystone.

b. ——— indurated claystone.

c. ——— clinkstone.

d. ——— compact felspar.

The colors vary with that of the base. They usually are found together with the simple rocks forming the bases.

C. Crystals of felspar imbedded in a simple or apparently simple base. Porphyry.

Bases *a. b. c. d.* as the preceding.

These are the most common simple porphyries. The crystals may be common or glassy felspar, or both. The felspar is sometimes opake and dull, as if beginning to decompose; at other times it is powdery. And again the place may be partially filled with an ochry powder, the mass appearing carious.

The colors of course are liable to all the varieties of the simple rocks forming the bases; other

varieties arise from the color of the crystals, or their mode of disposition. The cross crystals are the most remarkable. By the gradual exclusion of the crystals, the porphyries pass into simple rocks. They occur in veins and in mountain masses.

The var. *a. b. c.* are found mostly among the later secondary rocks, but occasionally even with granite. like their bases, with var. *d.* This last is most seen with rocks of older date. They are all occasionally laminar, and columnar, like some syenites.

—*e.* Base of basalt. Basaltic porphyry.

The basalt is of any of those substances usually called so—and the crystals frequently glassy.

Third Division.

Compounds of three or more ingredients.

First Sub-division.

— *Granitiform mixtures.*

A. Felspar, hornblende, and quartz. Syenite.

This alone is the compound which accords with the common definition of Syenite. Although the definition is upheld, it is constantly violated in practice.

The felspar may be compact or common: the former being found among the overlying rocks

only—and never, perhaps, among granites, whereas the latter compound is very prevalent with granite, of which it is a variety well known. When found with trap rocks the color of the felspar is often greenish, and the quartz being overlooked, the compound has been termed greenstone. The aspects and colors of this compound, of course, vary greatly, and depend upon the color, proportion and size of the ingredients.

B. Felspar, hornblende, and mica.

This is not common: and has been termed micaceous greenstone.

C. Felspar, hornblende, and chlorite.

D. ———————— and steatite.

E. Felspar, quartz, hornblende and mica.

The var. C. D. are rare. Notwithstanding the similarity of var. E. to granite, its situation places it among these rocks. It appears to be the compound that has been called new granite.

It is said that no mixture of quartz, mica, and felspar, has occurred among the superincumbent rocks.

The constituents of these syenites may be crystalised, as in granite. These varieties are sometimes laminar as well as columnar.

F. Augit, felspar, and mesotype.

G. Augit, felspar, and prehnite.

H. ——————————calcedony, or quartz.

I. ——————————calcedony, and prehnite, or mesotype.

These are varieties of augit rock.

K. Augit, felspar, and olivin.

L. Hornblende, felspar, and epidote.

These varieties are accidental or limited.

M. Hornblende, felspar, and prehnite; sometimes with the addition of mica.

The prehnite forms a decided constituent in this rock.

N. Hornblende, common felspar, compact felspar, quartz and steatite, and apparently augit. Found very rarely.

O. Hornblende, and greenish compact felspar forming the chief part of a mixture in which are intermingled glassy felspar, opake white felspar, augit in prisms, and mica, with pyrites.

All these complicated varieties can be referred to no other than the superincumbent or overlying rocks.

Second Sub-Division.

One species of crystals imbedded in a compound base, or two species of crystals imbedded in a base that is either simple or compound. This includes all the remaining porphyries.

A. Felspar crystals in a base of greenstone.

This is the greenstone porphyry, exhibiting different aspects according to the quality of the base They may be distinguished by a reference to what has been said above.

B. Felspar crystals in a base of syenite.

The same remarks apply to this variety, which passes insensibly into porphyritic granite.

C. The crystals consisting of felspar and quartz.

D. ——————————————mica.

E. ——————————————talc.

F. ——————————————epidote.

G. ——————————————pinite.

H. ——————————————chlorite.

I. ——————————————hornblende.

In many of these cases, it is difficult to ascertain if the crystals be imbedded, or if it form part of the base: and in such cases a gradation exists between granitiform and porphyrtic mixtures. Often the cavities of porphyries, like amygdaloids, are empty.

Fourth Division.

Supra-compounded rocks.

This division embraces many of those enumerated in the preceding catalogue as bases, in which nodules of several adventitious minerals are imbedded. Amygdaloids.

indurated clay B. div. 1st different varieties, is the most frequent base.

The porphyritic and amygdaloidal structures may be combined, and thus produce many incidental varieties. The amygdaloids may contain one or more minerals, giving rise to several varieties.

The size of the nodules, and their quantity diversify the aspect. The nodules do not always fill the cavity that contains them. Two or more minerals sometimes occur in the same cavity, as agate and calcareous spar. The amygdaloid may have large portions containing empty cavities, others partially—and others wholly filled—resembling sometimes cellular or scoriform lavas.

The transition is often imperceptible from simple rocks to amygdaloids.

From these circumstances the variety of amygdaloids is great: those containing the calcareous spar and the zeolites are the most abundant. The nature of the imbedded mineral, the characters of the bases, and the many combinations give rise to too many modifications to enumerate them all. The list of minerals contains those usually found, and in the order of their relative frequency: viz.

Siliceous Minerals.

Calcedony: variously colored, zoned, and striped: onyx; agates.

Cacholong; and semi opal.

Hyalite.
Heliotrope.
Brown carnelian : calcedony colored by chlorite.
Chert.
Quarz, with different degrees of opacity.
Amethyst.

Zeolitic Minerals.

Mesotype	Prehnite
Nadelstein	Laumonite
Analcime	Ichthyophthalme
Stilbite	Harmotome.
Chabasie	

Calcareous Minerals.

Carb. of lime	Flour spar
Brown spar	Arragonite.
Schiefer spar.	

Miscellaneous Minerals.

Sulphat of barytes	Steatite
Sulphat of Strontian	Lithomarge
Olivin	Chlorophœite
Epidote	Conite
Mica	Leucite.
Chlorite.	

Metallic Minerals.

Specular iron	Copper
Pyrites	Galena.

The following minerals sometimes occur in the preceding rocks: and may be considered as adventitious.

Apatite	Garnet
Tourmaline	Opal
Abestos	Meionite
Schiller spar	Sommite.

The two last perhaps belong rather to lavas than traps. They have all been found in recent greenstones and basalts.

Precious opal and chrysoprase occur occasionally in certain porphyries.

The amygdaloids generally occur in large masses: rarely in veins. In both cases, they are occasionally laminar.

Fifth Division.

Conglomerates.

The substance included under this head, is also mentioned under Conglomerate rocks.

A. Fragments of different trap rocks and of various sizes, angular, and re-united into a solid mass.—Trap tuff.

a. Fine, tuffaceous.

b. Conglomerated; coarse. Trap conglomerates.

They form beds or masses intermixed with the other varieties. Sometimes they contain portions of carbonised wood, or of foreign rocks—and may then be called transported conglomerates.

SYNOPSIS OF VOLCANIC ROCKS.

Preliminary remarks.

Geologists are much divided as to the substances that strictly come under this head. Where volcanoes have been long extinct, and some of the most decisive characters have been lost, much dispute

has arisen as to the substances that formed part of the mountain previous to the existence of the volcano, and as to those acknowledged to have been the produce of it. The chief difficulty however arises from the trap rocks, which are attributed by some to aqueous by others to igneous origin; and many of which so closely resemble volcanic products, that they are thought to be of similar origin.

The structure is the same as that of the trap family: viz. the prismatic, and lamellar, as well as the cavernous, amygdaloidal and porphyritic.

Respecting the imbedded minerals, much dispute has arisen as to whether they are ejected unaltered, whether they are formed in the lava by chemical affinities, or whether they are not produced by infiltration.

First Division.

More or less perfectly vitreous.

First Sub-division.

Solid.

A. Obsidian: volcanic glass.

a. Massive.

b. With an imperfect laminar structure.

c. Concretionary; imperfectly spheroidal or granular.

d. Fibrous, loose—rare.

e. Porphyritic; inclosing felspar. Obsidian porphyry.

Black, dark green, pale muddy green, grey and brown are the usual colours. It is sometimes striped. The lustre and opacity vary. In one instance it has been found to contain mica.

Second Sub-division.

Cavernous.

A. Cavernous Obsidian: passes to pumice.

B. Pumice.

a. Simply cellular.

b. Cellular protracted, becoming nearly fibrous.

C. Scoria. Formed of a less perfect glass, and passing to porous lava.

Second division.

With a base of compact felspar; or supposed to be so.

A. Simple; solid, or imperfectly granular.

B. Porphyritic: pale volcanic porphries.

The pale lavas belong to this division. Felspar is not necessarily the only imbedded mineral.

Third Division.

With a base of basalt, or some analogous substance, simple to the eye.

A. Simple: dark lava, and scoriform lava.

a. Compact: compact lava.

b. Porous: cavernous lava, or scoria; The caverns are often partially filled with substances entering into volcanic amygdaloids, into which this passes.

c. Prismatic, or columnar: volcanic basalt of writers.

d. Concretionary on a smaller scale: spheroidal or otherwise,

B. Compound: containing felspar: porpyries; other minerals beside felspar may be imbedded.

C. Compound: containing amygdaloidal nodules: Volcanic amygdaloid.

The imbedded nodules are usually calcareous or fluor spar, zeolitic minerals and calcedony. As they are some times accompanied by water, they seem to have been produced by infiltration. The colors are black, brown, grey, &c. depending often on the number and nature of the imbedded minerals. A list of imbedded substances will be seen presently.

Fourth Division.

With a base of greenstone, or some analogous compound. Augit seems to have usurped the place of hornblende.

A. Simple.

B. Porphyritic.

C. Amygdaloidal.

This division contains similar varieties with the last.

Fifth Division.

With a base of common felspar.

These are granitic compounds, but distinct from ejected granite. All these lavas present various modifications of external form, arising from the manner in which these have flowed, and similar to those found in the slags of furnaces.

Sixth Division.

Ejected substances, more or less altered by the fire.

First Sub-division.

Solid: conglomerates.

A. Conglomerates of various fragments of different rocks, with mica, augit, and other minerals.

B. Conglomerates consisting chiefly of clay, and having apparently, been ejccted in the state of mud. Tufa.

a. Coarse tufaceous conglomerates.

b. Fine and powdered tufa.

These latter varieties often containing augit, mica, and other imbedded minerals, as well as the solid lavas.

Second Sub-division.

Loose.

A. Fragments of various rocks, both primary and secondary, more or less altered by the fire.

B. Powdery, puzzolana, dust, ashes.

The following are the chief imbedded minerals found in these rocks. The amygdaloidal minerals are not added.

Felspar	Melanite
Pyroxene	Idocrase
Garnet	Toumaline
Hornblende	Apatite
Peridot	Zircon
Mica	Ice spar
Hauyne	Pleonaste
Meioniete	Arragonite
Melilite	Sphene
Tabularspar	Oxydulous iron
Sommite	Copper
Leucite	Selenium.

SYNOPSIS OF CONGLOMERATE ROCKS.

Preliminary remarks.

Many of the rocks noted under this head, have already been mentioned—but for sake of more easy reference are again introduced among the more important varieties.

These rocks occur among the primary and secondary strata, and are sometimes very limited, at others occupying extensive tracts. They may be divided into general and local.

The former constitute portions of those mixed rocks, whose origin is mechanical, and are formed of large fragments of the same substances, which, when in more minute division compose the finer strata. They must of course contain both simple and compound rocks of older origin than themselves—as for example, the red sand-stones and argillites. The materials are united without any distinct cement of a crystalline nature, particularly in the secondary class: and the fragments are more or less rounded. In some instances they seem to be only portions of the finer rocks which they accompany, in others they form extensive strata.

Local conglomerates are generally confined to the superficies of some simple rock—and are most various in lime-stones. Their composition is regulated by that of the adjoining rock. When between different rocks they contain fragments of both generally angular These remain where their parts were united but, in general conglomerates the constituents have undergone transportation. The one arising from simple fracture and re-union —the other originating from important and extensive revolutions—and may be called the consolidated alluvia of former ages.

The minerals entering into the local conglomerates are few, and are most frequently united by distinct cement—of fine materials, or of crystalline matter, particularly among calcareous conglomerates.

Trap conglomerates are local, and are formed by operations peculiar to those rocks—sometimes containing bituminous wood and fossil remains.

First Division.

Consisting of fragments of one rock, either imbedded in a continuous base of the same substance, or re-united chiefly by minuter fragments, or united by veins of carbonate of lime, or of quartz.

A. Consisting of limestone alone: local.

a. With angular fragments.

This occurs among primary and secondary rocks—and includes the ornamental breccia-marbles. It is local, confined to some simple limestone. The union is effected by carbonate of lime.

b. With rounded fragments.

The materials, which may be primary or secondary, have been transported. It does not occur in large strata or masses—nor attached to any particular rock, as the preceeding.

B. Consisting of fragments of quartz, or quartz rock alone united in various ways.

a. With angular fragments.

Local—connected with quartz-rock—of course primary.

b. With rounded, or angular and rounded fragments together.

One of the varieties of quartz-rock, under which head it is mentioned.

C. Consisting of fragments of jasper, united by quartz or calcedony:—agate—local.

D. Consisting of fragments of gneiss, of various sizes, agglutinated.

This variety is local—attached to gneiss—and forms the first bed of primary sandstone, where that rock rests on gneiss: it is necessarily primary.

E. Consisting of fragments of argillite, re-united by smaller particles or by clay—or imbedded in a continuous schist.

It is primary and local—and noticed under the head of Argillite. It may occur as secondary, and transported.

F. Consisting of chlorite schist formed similarly to E: local.

Accompanies chlorite schist, and is primary.

G. Fragments of the different trap rocks re-united by finer particles of the same.

a. With angular fragments.

Trap tuff, mentioned among the overlying rocks: local.

b. With rounded and angular fragments both. The materials are transported—but this is confined to the vicinity of trap rocks—and often of partial occurrence. May be either primary or secondary.

Similar Conglomerates may occur, consisting of the fragments of mica schist.

Second Division.

Consisting of two rocks or substances, united similarly to the varieties of the former division.

A. Serpentine and limestone; or calcareous spar: local. It generally occurs between limestone and serpentine—and is necessarily primary—it includes the verde antique.

B. Fragment, of argillite with limestone.

a. Argillite imbedded in limestone.

b. A confused mass of fragments of both.

c. Fragments of limestone imbedded in argillite.

These are primary—and some of them valuable.

C. Fragments of limestone imbedded in mica schist: local.

D. Fragments of granite with mica schist or gneiss: local.

a. The fragments of granite imbedded.

b. Confused mass of fragments of granite, and of mica schist, or gneiss.

E. Granite uniting fragments of the same rocks and offering similar modifications.

Where mica, schist or gneiss approximates to granite the latter often contains so many fragments of those rocks as to seem conglomerate.

F. Quartz imbedded in limestone: local.

a. In angular fragments.

b. In rounded pebbles.

These are both primary and secondary.

G. Trap imbedded in limestone, and in the accompanying shale: local.

The trap is usually in rounded nodules—and apparently weathered: occurs in secondary limestone.

H. An aggregate of fragments of argillite and chlorite schist: local.

This occurs where the two rocks accompany each other, and is local.

I. Sandstone with quartz.

a, The quartz in angular fragments.

b. The quartz in rounded nodules, or united with angular fragments.

H. Sandstone and lime united.

a. Fragments of sandstone imbedded in limestone.

b. Fragments of limestone imbedded in sandstone.

c. An aggregate of the fragments of both.

These are general and belong to the secondary sandstones—mostly to the lowest.

They are mentioned under the heads of the different rocks to which they belong.

L. Sandstone and argillite, or shale, united: general. The sandstone usually forms the base: is enumerated under that head.

Third Division.

Consisting of three or more rocks, o substances united.

These are the most common: they consist of fragments, rounded or angular, or both, united by means of clay, sand, and gravel, derived from the same substances.

A Fragments of quartz, and of a greater or less number of primary rocks, united.

In various states, this forms conglomerates attached to sandstones, under which head it is mentioned. It may be primary or secondary, the former containing the more limited number of ingredients.

B. Fragments of primary rocks with limestones.

C. Fragments of the same rocks with trap.

This is similar to A. and is found in connection with trap.

D. Fragments of granite, limestone, quartz and gneiss imbedded in mica schist.

This is found where limestone accompanies mica schist—or where the latter rock and gneiss approximate to granite.

E. Fragments of several primary or secondary rocks, or both, with fragments of trap.

This is a trap tuff, and noticed with the overlying rocks. It is in this and a few similar varieties of the most recent origin that organic remains have occasionally been found.

Some of the finer varieties of these rocks are noticed under the head of argillite, being frequently termed greywacks.

TABULAR ARRANGEMENT

OF

FORMATIONS,

Observed in both Hemispheres (1822)

BY

BARON HUMBOLDT.

Roman numerals are perfixed to the names of those formations, which being very seldom wanting, and consequently extending most generally, may be considered as geognostic horizons.

Primitive Formations.

I. Primitive granite.
   Primitive granite and gneiss.
   Stanniferous granite.
   Weistein with serpentine.
II. Primitive gneiss.
   Gneiss and mica-slate.
   Granite posterior to gneiss, anterior to mica-slate.
   Primitive sienite ?
   Primitive serpentine ?
   Primitive limestone.

The five latter formations, placed between gneiss and primitive mica-slate, are parallel formations.

III. Primitive mica-slate.

Granite posterior to mica-slate, anterior to clay slate.

Gneiss posterior to mica-slate.

Greenstone slate ?

IV. Primitive clay slate.

Quartz rock.

Granite and gneiss posterior to clay slate.

Primitive Porphyry.

V. Primitive euphotide, posterior to clay slate.

The four latter formations, are parallel to each other, sometimes even to primitive clay slate.

Transition Formations.

I. Granular talcose limestone, transition mica slate, and grauwacke with anthracite.

II. Transition porphyries and sienites, immediately covering primitive rocks; black limestone and greenstone.

III. Transition clay slate, containing grauwacke, greenstone, black limestone, sienite and porphyry.

IV. & V. Porphyries, sienites, and greenstone posterior to transition clay-slate, some times even to limestone with orthoceratites.

VI. Transition euphotide.

Secondary Formations.

I. Great coal deposit, red sand stone, and secondary porphyry (with interposed amygdaloid, greenstone and limestone.)

Secondary quartz rock,

The latter formation is parallel to coal-sandstone.

II. Zechstein or alpine limestone (magnesian limestone): hydrated gypsum; rock salt.

The five following formations which are very unequally developed may be comprehended under the general name of

III. Arenaceous and calcareous deposits (marly and oolitic, placed between the zechstein and the chalk, and connected with these two formations.)

Clay and variegated sandstone (sandstone with oolite; sandstone of Nebra; new red sandstone and new red marl) with gypsum and rock salt.

Muschelkalk (shell, limestone; of Gottinguen.)

Quardersandstein (sandstone of Konigstein.)

Jura limestone (lias, marle, and great oolitic. deposits.

Ferruginous sand and sandstone, secondary sandstone with lignite (iron sand and greensand.)

IV. Chalk.

Tertiary Formations.

I. Clay and tertiary sandstone with lignite (plastic clay, molasse, and nagelfluhe of Argovia.)

II. Limestone of Paris (calcaire grossier, or limestone with cerithia, a formation parallel to the London clay. and to the arenaceous limestone of Bognor.)

III. Siliceous limestone, gypsum with bones, alternating with marl (gypsum of Montmatre.)

IV. Sandstone, and sand above the gypsum with bones—(sandstone of Fontainebleau.)

V. Fresh-water formation with porous millstones (meuliere above the sandstone of Fontainebleau (limestone with (lymneæ.)

Formations (exclusively) volcanic.

I. Trachytic formations.

Granitoid and sienitic trachytes.

Porphyritic trachytes (feldspathic and pyroxenic.)

Phonolites of trachytes (simi-vitreous trachytes.)

Pearlstone with obsidian.

Millstone and cellular trachytes, with siliceous nodules.

Trachytic and pumce conglomerates, with alumstone, sulphur, opal, and opalised wood.

II. Basaltic formations.

Basalt with olivin, pyroxene, and a little hornblende.

Phonolite of basalt.

Dolerite.

Cellular Mandelstein.

Clay with pyrope garnets.

This small formation seems to be connected with the clay with lignite of the tertiary formation. over which currents of basalt are often spread.

Conglomerates with basaltic scoriæ.

III. Lavas that have issued from a volcanic crater (ancient lavas, vast masses generally abounding in felspar; modern lavas with distinct currents of small breadth; obsidian with lava and pumice of obsidian.)

IV. Volcanic tufa, with shells.

Deposits of compact limestone, mar[illegible] clay with lignite, gypsum and oolite, super posed on the most modern volcanic tufas. These small [illegible]cal formations belong perhaps to the tertiary rocks: Table-land of Rio-bambo: isles of Fortaventura and Lancerote.

ARRANGEMENT OF ROCKS,

On the principles of Werner, by his pupil Professor Jameson, of Edinburgh, and which may be considered as "Werner's own"—as it is probable that the celebrated Geognost would have made similar modifications in his original arrangement.

Class I. *Primitive Rocks.*

1. Granite, with Sienite and Topaz rock.
2. Gneiss, with Whitestone.
3. Mica slate.
4. Clayslate (Argillite.)
5. Primitive limestone, and Gypsum.
6. Primitive trap.
7. Serpentine.
8. Euphotide, or Diallage rock.
9. Porphyry.
10. Quartz rock.

Class II. *Transition Rocks.*

1. Greywacke, including transition Clay slate
2. Limestone.
3. Granite, and Porphyry
4. Gneiss, and Mica Slate.
5. Serpentine.
6. Quartz rock.
7. Red sandstone.
8. Trap.
9 Gypsum.

Class III. *Secondary Rocks.*

1. Sandstone, including the coal formation.
2. Limestone, including Chalk.
3. Gypsum, including Salt.
4. Trap, including secondary Sienite.

Class IV. *Alluvial Deposits.*

Class V. *Volcanic Rocks.*

TABULAR VIEW

BY

DR. MACCULLOCH.

I. Primary Class.

Unstratified.

Granite.

Stratified.

Gneiss	Red Sandstone.
Micaceous Schist	Argillaceous Schist.
Chlorite Schist.	Diallage Rock.
Talcose Schist.	Limestone.
Hornblende Schist.	Serpentine.
Actynolite Schist.	Compact Felspar.
Quartz Rock.	

II. Secondary Class.

Stratified.

Lowest (red) Sandstone.	Limestone.
Superior Sandstones	Shale.

Unstratified.

Overlying (and venous) Rocks.	Pitchstone.

III *Occasional Rocks.*

Jasper.	Gypsum.
Siliceous Schist.	Conglomerate Rocks.
Chert.	Veinstones.

Appendix.

Volcanic Rocks.	Alluvia.
Clay, marl, sand.	Lignite.
Coal.	Peat.

LIST OF FOSSILS FOUND IN THE UNITED STATES

MEGATHERIUM
MEGALONYX
MASTODON
ELEPHAS
BOS
CERVUS
BALENA
MANATUS

ICTHYOSAURUS
PLESIOSAURUS
SAUROCEPHALUS
TESTUDO

SQUALUS
RAIA
ACIPENSER and many undetermined genera and species*
MEDUSA
CANCER
TRILOBITE
ASTERIA
ECHINUS
CARYOPHILLIA
PENTREMITE.
ENCRINITE

AMMONITE
NAUTILITE
BELEMNITE
ORTHOCERATITE
NATICA
OLIVA
CARDITA
BILOBITE

TEREBRATULITE
ARCA
MACTRA
DONAX
OSTREA
GRYPHEA
PERNA
PATELLA
CONUS
CONULARIA
TEREBELLUM
MUREZ
STROMBUS
TURBO
PLANORBIS
TURRITELLA
SERPULA
BALANUS
GLYCEMERIS
CYTHEREA
PRODUCTUS
PENTAMERUS
VENUS
CARDIUM
CARDITA
VENERICARDIA
CUCULLÆA
ANOMIA
NERITA
PECTUNCULUS
TRIGONIA
MYTILLUS
AMPHIDESMA
CORBULA
PANOPŒA
CRASSATELLA
ISOCARDIA
CALYPTREA
LUCINA
ASTARTE
FUSUS
FULGUR
DISPOTŒA

* In a paper recently read before the Lyceum of Natural History, Dr. Dekay has attempted to show that nearly all the fossil fish from the great depository at Westfield (Mass.) and which have been referred to the genus Paleothrissum of Blainville, are not generically distinct from the Esox Osseus, or bony scaled pike of the Mississippi

PECTEN
HELIX
PLICATULA
SERPULA
CELLAPORA
MILLEPORA
ALVEOLITE
FAVOSITE
TUBIPORA
TURBINOLIA
ASTREA
MADREPORA
OCULINA
CORALLIUM
PENNATULA
SERTULARIA
ALCYONITE
ORBULITE
BACCULITE
FASCIOLITE
DENTALIUM
AMMONITE
NUMMULITE
SPIRULA

FELICES
PALMA
QUERCUS
JUGLANS NIGRA
FAGUS.

The following fossils have been enumerated by Dr. Bigsby in his geological papers on the country around Lakes Huron and Erie.

TRILOBITE
AMMONITE
ORTHOCERATITE
CONULARIA
TEREBRATULÆ
PRODUCTÆ
ENCRINIS
CARYOPHILLIA
TURBINOLIA
ASTREA
CELLULAR and chain MADREPORES, STRUES, and RAMOSA, RETEPORES and FLUSTRA, in great abundance. Nine new varieties of MADREPORES
LINGULA
CALYPTRÆA
CERITHEUM
UNIO
MYTILUS
GRYPHEA
ARCA
LILLY & PEAR ENCRINITE.

THE END.